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MORE EXPLORATIONS ROUND NANDA DEVI

ERIC SHIPTON

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MOUNTAINEERS will have been interested to learn that the Survey of India is now engaged on a new half-inch survey of the mountain regions of Kumaon and Garhwal. Previous surveys, as produced on the present ¼-inch sheets 53 N and 62 B, had been confined almost entirely to the populated and revenue-producing areas in or near to the great arterial valleys. Most of the glacier-covered country and the remoter valleys of these sheets are very sketchily drawn, in many places indeed so sketchily as to bear no resemblance whatever to the ground in question. Over much of the country too it has been found necessary to extend the primary triangulation. While engaged on this task in the Badrinath–Kedarnath range, Major Osmaston found that the whole trunk of the Gangotri Glacier was in fact several miles west of the position allotted to it on the map. I hope that now at last we shall have a final solution to the topographical problems which, as a result of the vague data recently brought back by various expeditions, have excited so much discussion.

The usual method employed for hill surveys in India is plane-tabling by Indians, who are each responsible for a section of the area. They work with remarkable speed and neatness, and under close supervision of their officers they produce very good work. But in the high Himalaya they are faced by unusual difficulties. Not being trained mountaineers they have great difficulty in moving their parties about in the glacier regions and in reaching suitable stations. Owing to the peculiar difficulties presented by the country round Nanda Devi it was decided to depart from the usual practice and to send Major Osmaston, who is in charge of these mountain surveys, to carry out a photographic survey of the basin drained by the Rishi Ganga. As I had made a reconnaissance of the region in 1934, the Survey Department invited me to accompany the party in order to assist Major Osmaston with the route and in the selection of suitable stations.

A Wild photo-theodolite and one hundred plates were taken as well as a

plane-table. I took with me the Watts-Leica photo-theodolite belonging to the Society, partly to supplement the main survey, and partly in order to give a further test to this novel instrument.

Six Sherpa porters were brought from Darjeeling, including Angtharkay. The name Sherpa has almost become generic for all porters engaged in Darjeeling. Actually one of these men, Gyalgen, came from two months' journey north of Lhasa.

We left Ranikhet on August 27. We had to take an unusual route to the Kuari Pass as one of the bridges on the Wan route had been carried away by floods. We had terribly bad weather all the way to Joshimath. The rains reached their climax on the night of August 29 and our camp was flooded out. Later we heard that 10 inches of rain had fallen in Mussoorie that night. The 29th was the day on which Nanda Devi was climbed.

We reached Joshimath on September 3 and left again on the 6th. On the 7th we camped at Lata, near the mouth of the Rishi Ganga. As we were sitting in camp a bearded and tattered figure appeared rushing down the steep path. This proved to be Peter Lloyd, the first of the returning Nanda Devi party. From him we heard of their splendid achievement. In my opinion the climbing of Nanda Devi is perhaps the finest mountaineering achievement which has yet been performed in the Himalaya; it is the first of the really difficult Himalayan giants to be conquered. This expedition was a model of what such an expedition should be: their party consisted exclusively of mountaineers; they avoided the great mistake which to my mind nearly all the major Himalayan expeditions since the war have made, and did not handicap themselves with a vast bulk of stores and superfluous personnel; each man was prepared to carry loads up to any height, and indeed all were called upon to do so during the most arduous part of the climb; above all, they avoided newspaper publicity. I was delighted to hear that Tilman had been one of those to reach the summit. He had done more than his share of the donkey work, having earlier in the year ascended the Rishi Nala and dumped provisions in the "basin" and then returned all the way to Ranikhet to organize the transport of the party. Later that evening Graham Brown turned up. The rest of the party we met on the cliff track to Durashi, except for Tilman and Houston, who had crossed a very difficult pass to Milam.

The passage of the Rishi gorge was now quite devoid of difficulty. There were cairns at every turn, a small but adequate path wound across the steep slopes, and any rock pitches were cleared of loose rock and earth. The monsoon was still active and we had a lot of bad weather. However when we reached the basin on September 16 the days were gloriously fine and the nights clear and frosty. The rivers were already fast sinking to their low autumn level and they presented us with no difficulties.

Osmaston decided to tackle the northern section of the basin first. I was keen to examine the ridges and valleys leading from the main basin up to the peaks bounding the western flanks of the Rhamani and Bagini glaciers, as we had not had the opportunity in 1934 of exploring this area. This I was able to do while Osmaston was mapping this part of the basin. The peaks in this vicinity are mostly composed of a beautiful pale granite, and soar to their

21,000 feet in clean curving lines, supported below by wonderfully carved ice flutings.

Tensing, one of our Sherpas, had developed some sort of fever in the Rishi Nala and every day for more than a fortnight he ran a very high temperature—often as much as 105°. Even when he had recovered he was no more than a passenger, as the fever left him very weak and thin. Owing to this we kept on two of the Lata men who had accompanied us into the basin. They worked splendidly and with a little training would be as good as the Sherpas. It is time that some one undertook the task of training the people of Garhwal as mountaineers. There is any amount of splendid material in the higher valleys. They have one tremendous disadvantage however and that is that their religion forbids them to eat either with Europeans or anything cooked or touched by Europeans, or by Indians of other castes. When a party is engaged in a long and difficult task this taboo would produce an impossible situation. With the Sherpas I am in the habit of eating out of the same dish and drinking out of the same mug and no one loses caste or feels embarrassed. Later in the year when we were employing some Dotial porters and the party ran short of food, the Dotials, who had finished their own food, allowed themselves to become feeble with hunger rather than eat the rice which we had been carrying in our rucksacks. Angtharkay always becomes infuriated by this prejudice, and taunts the victims unmercifully.

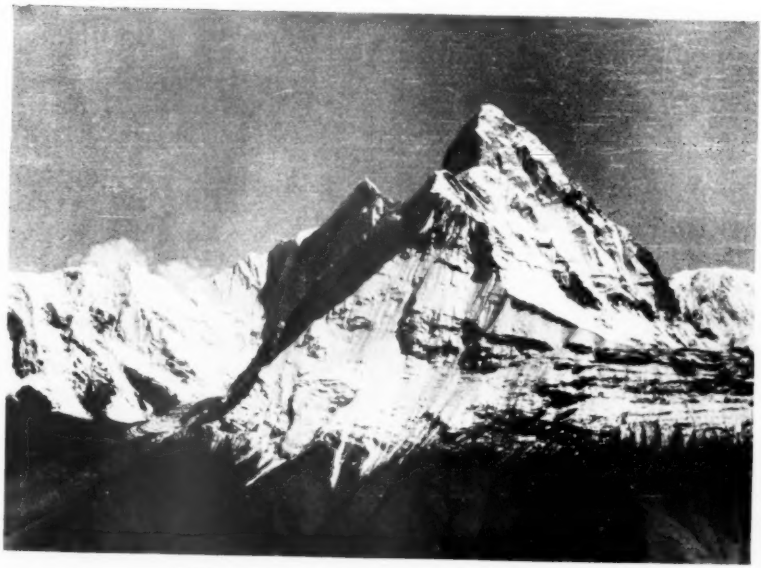
At the junction of the two great glaciers of the northern section we made a camp by the lake. We had brought a goat with us from Lata and at this camp we gave orders for it to be executed. It was a sad business as we had all become very attached to the animal. It had shared with us the fatigues of a long journey and the warmth and comfort of our caves and camp fires. It had been no easy task getting it up the gorge and Angtharkay who had been its keeper and principal helper was particularly distressed at the idea of killing it and had defended its life for some days with arguments for keeping it alive—the chief of these being that it might as well be made to carry its meat as far up the glacier as possible. That night however when eating fried liver and kidneys he had no regrets. The execution itself was performed by the two local men, who slashed open the belly and plucked out the heart before the animal had time to bleat.

We crossed the Great North Glacier, which was a severe trial to Sen Tensing, who was now so weak that he found difficulty in walking. His temperature was still alarmingly high in the evenings, and we were beginning to get very worried about him. However in the large ablation valley on the other side of the glacier we made a base camp from which the remainder of the northern section could be reached. After a week's rest at this camp the fever left him. Angtharkay, Ang Dawa and I set out to climb a fine triangulated peak (21,770 feet) on the watershed overlooking the Milam Glacier. We camped at about 17,500 feet in a subsidiary valley and started before dawn the following day (September 23). We climbed up a steep and quite difficult ice ridge which involved a great deal of step cutting. The conditions were excellent however and the climb was pleasant and safe. Ang Dawa was quite the strongest of our six Sherpas: in fact he used to entertain us in camp with feats of strength. In the Rishi Nala too he had displayed considerable skill

on steep rocks and would run about over precipices without turning a hair. On this ice-ridge it was very surprising to see him crack up. He could not adjust his movements to the ground he was on and was terrified on steep snow slopes. He became exhausted early in the climb and a few hundred feet from the summit gave up the struggle. This delayed us a good deal and by the time Angtharkay and I reached the top the Milam glacier was filled with cloud and I did not get the view I had hoped for. We looked down on two gorge-like glacier valleys running eastward from the two cols on the watershed on either side of the peak. Lower down we could just discern their junction with the Milam glacier. It would be possible to cross either of these two cols and so to reach the Milam glacier from the Nanda Devi basin, though it would be a difficult undertaking with the loads it would be necessary to carry.

Though the peak we had climbed is the highest on that part of the watershed, in common with most of the great peaks of the Nanda Devi basin it has no name. With the new survey of the range a complete revision of the nomenclature of the district is being made. It is no easy task to decide on the most appropriate name for peaks and glaciers. Each group of villages has a different name for the same feature and they do not agree even upon the names of the great peaks which dominate the whole district. Thus all the peasants of the Dhaoli Valley, in the vicinity of the mouth of the Rishi Ganga, call Nanda Devi Nanda Ghunti and have never even heard of the former name. The peak known to us as Dunagiri is called by these people Tolmai Pahar, and it is only in the vicinity of the village of Dunagiri in the Bagini valley that one hears the name Dunagiri used for the mountain. On the other hand, the shepherds of the Rishi call the glacier which flows down from Changabang into the Rishi Nala the Bagini, whereas Bagini is the name given by the Dunagiri villagers to the great glacier in their valley. This state of affairs is found throughout the district—and indeed throughout all mountain districts I have travelled in, in Africa as well as the Himalayas. It is not surprising that it should be so. The peaks and glaciers are as yet of no economic value to the peasants, and to them only the grazing grounds, streams, and forests are worth naming. Thus the most prominent peak standing above a grazing ground would simply take the name of that grazing ground as indicating roughly its direction when seen from afar, while the shepherds on the opposite side of the peak call it after *their* nearest grazing ground. In this way the traveller is confronted by several peaks known by the same name and several different names given to each of the peaks. It seems to me that the best solution is for the pioneer travellers to adopt the pleasantest sounding of the various names, for geographers to accept their suggestions, and for subsequent travellers to refrain from discussion. In the case of uninhabited areas such as the Nanda Devi basin, none of the glaciers or lesser peaks has a local name and there are a great many 22,000 and 23,000 feet peaks which, though triangulated, cannot be seen clearly from the inhabited valleys, and remain unnamed. In these cases it is the duty of explorers to invent suitable names for all prominent features, and map producers should make an effort to adopt their suggestions. A tremendous amount of confusion and misunderstanding is caused by procrastination in this matter. We have produced a list of names

Nanda Devi and the Bagini watershed



Twin peaks of Nanda Devi from the west

Dunagiri, Changabang, and Kalanka

The peaks north of the Bagini Glacier

for peaks, glaciers and lakes of the Nanda Devi region which will be considered by the authorities when the map has been drawn.

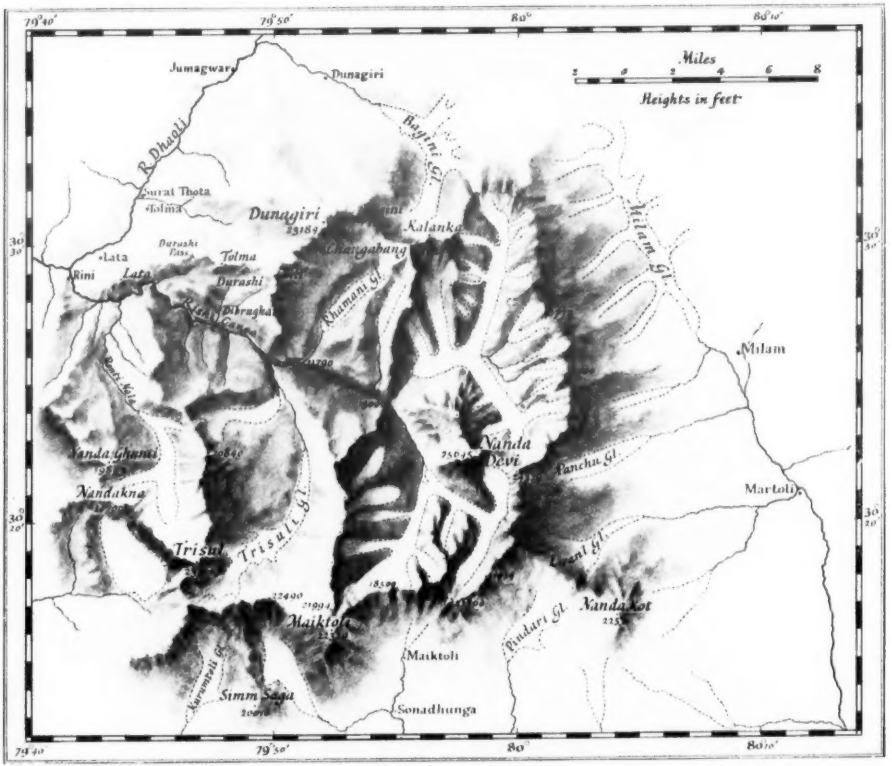
After accompanying Osmaston up the Great North Glacier (which will be given a more suitable name in due course) I returned to the lake, and from there went with Rinzing Bhotia up the Changabang glacier. The moraine which covers the greater part of the surface of the ice is made up of huge blocks of that remarkable white granite of which the cliffs of Changabang are composed. Half-way up we camped on the flat top of a glacier table. Except for the fact that the table might have collapsed, it made an excellent camp site. The weather turned bad, and that evening a good deal of snow fell. Starting before dawn the following day (September 27) we reached the head of the glacier which rises in a cirque of stupendous granite cliffs. We were making for a saddle at the foot of the southern ridge of Changabang which I hoped would offer a practicable route to the head of the Rhamani glacier. A gully in the granite slabs led us to the crest of the col without much difficulty, and from there we looked down on to the great snowfield which Dr. Longstaff had reached after crossing the Bagini Pass in 1907. We were separated from it however by a vertical wall of rock whose smooth face it was quite impossible to descend. Although by now most of the peaks were covered by cloud, the view was magnificent and I sat for an hour fascinated by the gigantic white cliffs of Changabang. The great snow dome of Dunagiri appeared now and then from across the Rhamani glacier but I did not get a view of the main mass of the mountain. We descended to our camp in the afternoon and thence, in heavily falling snow, down the glacier to the lake. We returned to the glacier junction camp the following day to find that Osmaston had been delayed by the bad weather and still had one more station to do in the northern section. He had been right up to the head of the Great North Glacier and had completed the survey of that valley and its tributaries.

We descended the main glacier and crossed the rivers into the southern section. There I left Osmaston and went down the Rishi gorge to Dibrughata with Angtharkay and Sen Tensing, reaching there on October 3. We left again on October 4 and on the evening of the 5th reached a high pasture in the ablation valley of the Rhamani glacier. I was hoping to reconnoitre the south-west ridge of Dunagiri and, if time permitted, to make an attempt to climb the peak. On the 6th we went up a side glacier and camped on its moraine at about 17,000 feet. The following day we managed to reach a col nearly 20,000 feet high, connecting the south-west ridge of Dunagiri with a peak which on the old 1-inch maps bore the strange name "Niti No. 3." On the northern side of the col the ground fell away with tremendous steepness to the Tolma glen and we found ourselves looking straight down to Surai Tota in the Dhaoli valley. We turned right-handed and followed a narrow icy crest towards Dunagiri. Sen Tensing succeeded in dropping his ice-axe. We recovered it two days later, but its temporary loss produced a horrid feeling of insecurity for the whole party. Reaching a point where the ridge sweeps up with considerable steepness we pitched our tent under a great rock buttress. Later in the evening Angtharkay and I climbed several hundred feet further up the ridge to reconnoitre the route. We found that the going was over hard ice and that steps would have to be cut every foot of the way.

Our camp was in a superb position and commanded views from the great peaks of the Nanda Devi basin and the Trisul ranges to the mountains of Badrinath and Kamet. After a bitterly cold night we started before dawn, a very painful performance from which there was no relief until the sun appeared. We had left Sen Tensing behind in camp and Angtharkay and I took the labour of step-cutting in turns. It was very slow and tiring work, and when after some difficult climbing we reached the long, almost level ridge leading to the summit it was late in the day and we had not time to cut our way along the knife-edge crest to the top. The route however is quite feasible and, as far as I have been able to see, by far the best way of climbing this peak. We got to within 1000 feet of the top (23,184 feet).

We returned to the Rhamani glacier and camped at its head below the col which Rinzing and I had reached from the Nanda Devi basin. On October 10 we started to cross the Bagini Pass. I was rather confused by the topography at the head of the glacier. The western face of Changabang falls with its characteristic sweep of white granite to a col some 2500 feet below the summit. West of this the watershed ridge rises to a sharp conical peak, and then falls again to a long serrated granite ridge which nearly a mile further on abuts onto a peak (21,290 feet) of the great north-east ridge of Dunagiri. Between this peak and Dunagiri itself is another low depression which forms the watershed between the Rhamani and Dunagiri glaciers; this one however is almost inaccessible from this side. I was by no means certain which of these cols was the Bagini Pass which Dr. Longstaff had crossed in 1907 and as far as I know had not been crossed since. We chose the middle one and reached the crest of the serrated rock ridge at 12.30 on October 11, only to find that from where we stood there was no chance of descending on the northern side. We spent nearly the whole of the rest of the day moving ourselves and our loads along the knife-edged crest of the ridge before we could rope down into a gully through which a descent could be made. We were overtaken by dark when only about 200 or 300 feet down and had to construct a tiny platform on which to camp for the night. Early next morning we completed the descent of the rocks and ran down the snow-covered head of the Bagini glacier. The valley we were in was bounded on the east by a most magnificent wall of peaks, which form the north-western rim of the Nanda Devi basin on which we had stood two years previously. From lower down we could look up a small side glacier to the col under the western face of Changabang. I was extremely glad that we had not tried that route as it would have been almost impossible to descend from the col with our loads. The first crossing of the Bagini Pass must have been an anxious business; apart from the difficulty of the climbing Longstaff and his companions had no idea of where the pass would lead them, and even when they had negotiated the Rhamani valley they were still many days from habitation. We had none of these anxieties, and thus our passage was vastly easier.

The Sherpas were eager to reach fuel before nightfall, and we sped down the glacier without halting anywhere. Every step of the way was vastly interesting to me and I spent an absorbing day fitting in the topography of the Bagini glacier with our explorations of two years previously. We had magnificent views of the huge unnamed peaks of the Garhwal–Kumaon watershed.



The Nanda Devi basin, based on a plane-table survey by E. E. Shipton and H. W. Tilman

Immediately north of these peaks is the Girthi river which makes such a strange intrusion into this line of elevation. The sun had long set before we reached the first juniper on the southern side of the glacier and we were lucky enough to find a brook running down the ablation valley and soft turf on which to camp. The excitement of reaching juniper after some time on the higher glaciers never loses its force. In spite of the hardihood of this plant it is peculiarly sensitive to its position and at higher altitudes never grows on slopes with a northern aspect. For some miles that evening we had seen it growing on the opposite side of the glacier in tantalizing profusion, but it was not until the lateral moraine on our side became sufficiently large to produce a fertile south-facing slope that we came across any. The reverse is the case with rhododendron and birch, and at lower altitudes the aspect of one's camp is indicated by the different effect these woods have upon the food.

Next morning below the snout of the glacier we found a blaze of autumn colours. The bare, almost feathery branches of the birch woods contrasted with the brilliant green of rhododendron and juniper, and the whole valley was interlaced with vivid patches of red, flame, and copper. The glades were filled with long wavy grass the colour of ripe corn in the morning sunlight. In place of the raging torrents of muddy water which issue from Himalayan glaciers throughout the summer we found sparkling crystal streams. The air too had a sparkle of frost which enhanced the beauty of the autumn tints. Early in the day we reached the village of Dunagiri where we found all the population busily engaged in reaping their crops and storing the grain for the winter. The houses were decorated with huge yellow marrows and cucumbers. The whole valley seemed steeped in sunshine and the rich colourful ripeness of autumn hues.

The remainder of the day was spent basking in the sun outside one of the houses, chatting with the villagers who, to celebrate our arrival, indulged in a half-holiday. We were besieged with questions about our doings and the reasons for them; to these we gave the usual unsatisfactory answers, in return for which we received much interesting information about the valley and its people. It appears that in the autumn all the inhabitants descend as far as Karnaprayng and even further with their flocks, and the whole valley is deserted. All the farm produce is stored in the village for consumption during the following summer. The winter exodus takes place by slow degrees and was already in progress. The Sherpas spent a happy day trading old tins for food, and after some hours of hard bargaining had obtained, without spending a single *pice*, enough to keep us supplied for a week. The children in these villages are made to work from a very early age. In the evening I watched some tiny mites supervising with extraordinary skill the herding of enormous flocks into pens. There were innumerable lambs, each of which had to be placed by its mother. The children worked until long after nightfall settling the disputes and attending the bleated complaints of the sheep.

The following day I went up with Sen Tensing to investigate the so-called Dunagiri glacier and to reconnoitre the northern approaches of the peak. The glacier terminates in an immense wall of moraine debris which has been thrust into the birch forest high up the side of the main valley, a mile or

The Ronti Nala

so below the snout of the Bagini glacier. It is very much alive and appears at the present time to be advancing; in former ages it must have flowed far down into the main Bagini valley. It rises, not at the foot of the peak of Dunagiri as I had expected, but in a rocky cirque culminating in a peak (21,290 feet) whose acquaintance I had made on the opposite side. The north face of Dunagiri itself was half hidden from view by this cirque, but from what I saw I should say that any route on this side would be a great deal more difficult than that which we had reconnoitred a week before. The best approach to the foot of the north face would probably be up the *nala* which joins the Dhaoli about 3 miles below Jumagwar. I do not know whether any one has been up this *nala*.

I regretted leaving our friends of the Bagini valley and their charming village; their hospitality and kindness matched their beautiful surroundings. Further down the valley the autumn tints were even lovelier than they had been near the glacier. I spent nine months in the Himalaya last year and at no time did I see such a wealth of lovely things as during this October; even flowers were not wholly lacking and occasionally in some well-watered glen we would come across drifts of primulas defying the rule of the seasons. In my opinion there is no better time to travel in Garhwal than the autumn; the days are cool, the nights not too cold, snow conditions are good (except high up on north-facing slopes), and the weather is usually fine. An added advantage is that, with the newly reaped crops, it is very easy to live off the country. In the forest we came upon several small encampments of peasants, busily engaged in collecting the stones of wild apricots, from the kernels of which they make oil. Further down the Bagini torrent enters the main Dhaoli valley through a fine canyon which is not the least impressive feature of the very beautiful valley down which we had come. Two more marches took us to Joshimath where we rested for two days. I had been there only a couple of hours when Professor Heim arrived, and I was delighted to be able to spend the two days in his company. They had just completed a tremendous season of geological work in the vicinity of the Almora–Tibet frontier.

I left Joshimath with the two Sherpas and three Mana porters on October 18. Half-way to Tapoban I met Osmaston returning from his work in the Nanda Devi basin. The excellent weather of the last three weeks had enabled him to complete the survey of the southern section a great deal sooner than we had expected, and he had been supported in the Rishi Nala by Fazal Ali, probably the most competent of his plane-tablers. Fazal Ali had surveyed the Trisuli Nala at a remarkable speed, averaging nearly 5 square miles a day, which is fast going for such difficult country. He was now working in the Rhamani Nala, and later completed the mapping of the lower part of the Rishi gorge. Only one section of the outer basin remained; this was the valley running north from glaciers between Trisul and Nanda Ghunti. It had been decided therefore that I should make a survey of this area with the Watts-Leica photo-theodolite, with the dual object of rounding off the Nanda Devi survey and of trying out this instrument in an independent survey. Osmaston went off up to Badrinath with the object of inspecting his surveyors in that district. Most unfortunately one of his camp officers had died in the Arwa valley, and

although Captain Crone had gone up to deal with the situation, much reorganization was required.

We camped our first night out of Joshimath at Rini which is situated at the mouth of the Rishi Nala. The following day we enlisted the help of a local man to show us the best way to the highest pastures in a valley we were making for, and to help me in naming some of the prominent features. Dr. Longstaff has referred to this valley as the Rinti Nala, though the name used by the people of this district is more like Ronti. We followed the main gorge for a while by a path which has been very cleverly engineered by the peasants, but soon the going became difficult and we turned right-handed and climbed up over steep, heavily forested slopes past another tiny village basking happily in its rich, self-contained isolation. Higher up, the Rini man introduced us to a variety of wild fruits which grew in the forest, some of which were new to the Sherpas. The commonest of these resembled a crab apple on the outside, though its internal construction and taste were more like those of a persimmon. All through the forest there was a wonderful profusion of autumn colours. We put up plenty of Monal pheasants which sailed over our heads, screeching noisily. During the two days we were going through this forest we must have seen nearly a hundred of these birds. Even in this remote valley they were very wild and very rarely gave us a chance to get near to them.

We entered the Ronti valley several thousand feet above its floor, and on October 20 camped in a cave high up on the side of the *nala* and commanding a magnificent view of the surrounding country. The lower section of the valley in which we found ourselves is bounded on the east by huge precipices which culminate in a line of jagged aiguilles; but the western slopes are gentle and well wooded and frequented by shepherds from the villages in the neighbourhood of Rini. Their grazing ground was pointed out to me by the Rini man who called it Chamba Kharak. This part of the valley is enclosed by a great ice-covered wall which forms the eastern ridge of a peak (19,893 feet). Round the eastern end of this wall the valley runs up through a narrow gorge to a large glacier basin which forms its upper section. Through this gorge we could see the tongue of the glacier protruding. There has been a good deal of confusion regarding this peak (19,893 feet) and its southern neighbour (20,700 feet), which is such a prominent feature seen from Ranikhet and Almora. The present map labels the former Nanda Ghunti and the latter Nandakna. Dr. Longstaff however has always referred to the higher peak as Nanda Ghunti, and certainly that is what it is called by the inhabitants of the valleys to the south-west of the range. We found that the Rini villagers refer to the northerly peak as Ronti, and I hope that these two names will be adopted on the new map.

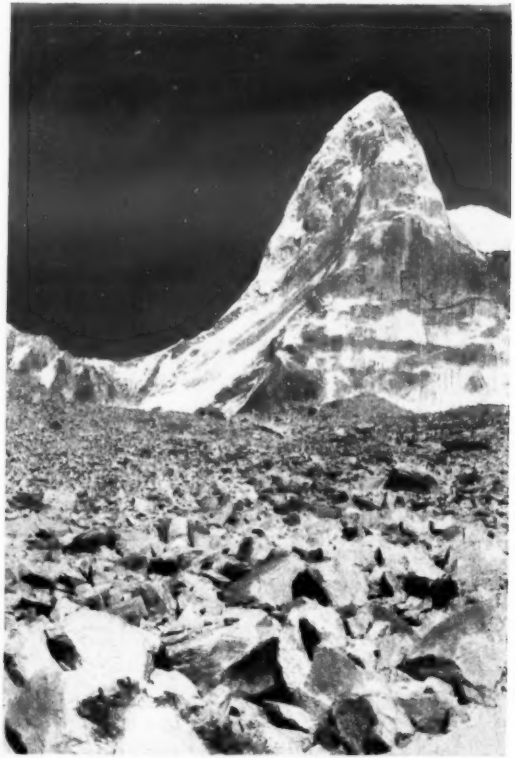
One of the Mana porters had been with Tilman's party and entertained us in the evenings by voluble descriptions of their adventures in the Rishi gorge during the monsoon. I was amused to find that these men had nicknamed Tilman "Balu Sahib" (*Balu* meaning a bear) owing to the speed with which he moves over steep forested ground. On reaching the Ronti Nala I discharged the local men and set to work with the two Sherpas on the survey. But the weather broke and we were confined to our cave for three days. A good deal of snow fell and it began to look as if winter conditions would

prevent any further work. Also I was afraid that our food supply would run too short to allow us to attempt to cross the pass over the watershed. However we had brought another sheep with us and occupied ourselves concocting fancy meat dishes. The morning of October 24 was fine, and by starting before dawn we managed to reach a high spur in time to take a round of angles and photographs before the mists rose out of the valleys and swamped the view. The dawn views were magnificent and showed nearly all the great peaks of this section of the range like islands washed by an ocean of flame-coloured cloud. In the afternoon we humped our heavy loads over to Chamba Kharak, from which I was able to do another station. We repeated this procedure every day until five stations had been completed in the lower section of the *nala*. As the view was invariably obscured by nine o'clock each morning it was difficult to put the stations sufficiently high, and we had to do twice as many as would have been otherwise necessary. The great advantage of this method of photo-survey over plane-tabling is the very short time that it is necessary to occupy a station. Plane-tabling in the conditions which we were experiencing would have been almost impossible. The photo-theodolite which I was using weighs 18 lbs. including stand and cases; it is extremely simple and convenient to use; and if it is found possible to plot with sufficient accuracy from the tiny photographs, it will bring photographic survey within the scope of even the most lightly equipped parties. Moreover the use of roll films instead of plates makes it much easier to bring back the results intact. The film is held flat while being exposed by means of a pressure glass in the back of the camera.

On the afternoon of October 27, in a heavy snowstorm, we made our way through the bottle-necked gorge which lies between the lower and the upper sections of the Ronti Nala. We were climbing on the moraine-covered ice of the glacier which squeezes itself through the gorge. Our great difficulty was to find any water, as at this time of the year all the glacier pools are hard frozen day and night and we could not afford the fuel necessary to melt ice at this stage, being then above the limits of juniper. I was surprised to find Monal pheasant far up the glacier. Up there they seemed extraordinarily reluctant to embark on their gliding downward flight and we got so close to them as to tempt the Sherpas to chase them with a fusilade of stones. Although the Sherpas threw with great accuracy, the birds seemed to have a cunning knack of hopping over the missiles, and we failed to replenish our larder in this way.

Fortunately the next day the weather became finer and we were able to make the best use of the short time in the upper glacier basin. We found it to be divided into three sections. Firstly, there was a large ice-stream coming down from the saddle between Nanda Ghunti and Nandakna. This saddle must lead to the headwaters of the Birch Ganga. I was very tempted to visit it but could not spare the time. Next there is a small tributary glacier rising under the western ridge of Nandakna; at the head of this is the saddle reached by Longstaff and Ruttledge from the other side. Thirdly, what is probably the main glacier flows under the ice-terraced cliffs of the north ridge of Trisul. Although the upper part of this was out of sight, I decided, when the survey was finished, to look for a way across the watershed in this direction.

The Kurumtoli Glacier



Changabang from the Rhamani Glacier

Head of the Kurumtoli Glacier

Shipton, and Angtharkay, with the Watts-Leica photo-theodolite

It proved to be the right line and we encountered no difficulties whatever. Our last camp and station were on the saddle itself and commanded glorious views on both sides of the range. The glaciers on the southern side are very small and we were soon back in heavily forested country. In the upper part of the Nandagini we saw large herds of game. Near the entrance to the Nandagini gorge, where we camped, we found signs of the visit of the surveyor who had been working in this area. In spite of this we found it quite difficult to follow his track in the jungle. Sen Tensing became separated from us, and Angtharkay and I retraced our steps for a long way in search of him. Instead of him we found a good path, which we concluded he must have been following. It was not however until late in the evening that we found him. He had not struck the path and had been struggling along some hundreds of feet below it. Angtharkay and I told him, untruthfully, that we had found a village in the afternoon and had been sitting there imbibing milk and baked potatoes. Angtharkay told him to go back to get food for himself from the mythical village. However I thought that was carrying the joke too far and stopped him.

From Sutol we crossed the Wan Pass to Gwaldam; and later from Wan we crossed into the valley of what, on the existing map, is called the Kurumtoli glacier which Dr. Longstaff explored in 1905. He calls it the Keil glacier. In this region I did several photographic stations, which were intended to supplement the work of the plane-tabler who had not had time to complete his work in this part.

On my way to Bombay I went to Dehra Dun where I met Osmaston and Captain Crone, whom I had seen previously at Joshimath. Osmaston's photographs had come out well except for a certain amount of fogging round the edges. Crone calibrated the camera I had been using and appeared to think that there would be no difficulty in plotting the data I had brought back. He is working on it now and I am anxiously awaiting his report on the work of this very handy little instrument.

DISCUSSION

Before the paper the CHAIRMAN (Dr. T. G. LONGSTAFF) said: Owing to the regrettable absence of the President through illness it falls to my lot to introduce the lecturer this evening, though I expect most of you know him well already.

Mr. Shipton is a very experienced mountaineer. He learnt his trade in the Alps, which are still by far the best school. In 1929 he climbed Mount Kenya with Wynn Harris. In 1930 he made with Tilman a very fine traverse of Mount Kenya by a new route, a very memorable expedition. In 1931 he was a member of the successful expedition to Kamet in Garhwal. In 1932 he was in Ruwenzori. In 1933 he reached 28,000 feet on Mount Everest. In 1934, with Tilman and only three Sherpas, he succeeded in effecting the first entrance into the inner sanctuary of Nanda Devi, having forced the upper gorge of the Rishiganga which had previously defeated all comers. In addition to that, they made two exceptionally difficult glacier passes, one over the main range to the south of Nanda Devi and the other over the main water-parting of the Badrinath group. In 1935 Shipton led the so-called reconnaissance expedition to Mount Everest, during the course of which his party climbed twenty-six peaks of over 20,000

feet, which is more than all the other 20,000-footers that have ever been climbed in the Himalaya put together.

In 1936 he accompanied the Mount Everest Expedition. The monsoon arrived too early and it was not possible to do anything. Therefore in the autumn, through the courtesy of Brigadier Couchman, he got leave to accompany Major Osmaston, who had been detailed by the Survey of India to make a map of the basin of the Nanda Devi and the gorges of the Rishi. And now, without telling you more about the paper, I will ask Mr. Shipton to read it.

Mr. Shipton then read the paper printed above, and a discussion followed.

The CHAIRMAN: I think Colonel Lewis, Surveyor-General designate of the Survey of India, is here to-night. If so, I would like him to come on to the platform to tell us something about the country, because the inception of the new survey is due to him; and, furthermore, it is due to his interest that Mr. Shipton was able to accompany Major Osmaston.

Colonel C. G. LEWIS: Two years ago the Survey of India decided to start the survey of the Tehri-Garhwal and Kumaon Himalaya between the Punjab and Nepal borders. The existing maps, over fifty years old, are quite inadequate for present-day needs, and in addition it was decided to increase the scale from $\frac{1}{4}$ inch to $\frac{1}{2}$ inch to the mile. In the first season we finished the area drained by the Bhagirathi River in Tehri State.

Last year, when we came to Kumaon, the problem of getting into the Nanda Devi sanctuary immediately presented itself. Some of our Indian surveyors who have had several seasons of training and experience in Chitral and Gilgit have become experts in the technique of alpine surveys but are quite untrained in mountaineering. It was unlikely that a surveyor by himself with local transport would succeed in penetrating into the sanctuary and unfair to ask him to make the attempt. It was therefore decided that Major Osmaston himself would have to do the survey, and at this juncture we found that Shipton was at a loose end. The Surveyor-General, Brigadier Couchman, was only too glad to avail himself of his help. The results, as you have just heard, were most satisfactory and successful.

I should like to say that the Survey of India has been considering for some years the question of names in uninhabited mountain regions. The situation was becoming almost intolerable. Last year the principle was adopted of selecting invented names given by explorers or by our own parties during the course of survey, so that names may now be given to peaks, passes, and glaciers which hitherto have been nameless.

I take this opportunity of thanking Mr. Shipton, on behalf of the Survey of India, for the great help he gave us last year in the survey of the Nanda Devi sanctuary.

The CHAIRMAN: Professor Graham Brown was with the British-American party which climbed Nanda Devi in 1936. We shall be very glad to hear something about that expedition, which was just prior to Mr. Shipton's.

Professor T. GRAHAM BROWN: In the summer of 1936 a party of eight of us—I wish there had been nine—started off into the Nanda Devi basin in order to climb that great mountain. I say I wish there had been nine because I wished to have Mr. Shipton with us on that particular occasion. His engagement with Everest delayed him and he was not able to join us. Had he done so he would not have been able to take part in this wonderful expedition that we have heard about to-night, and I am not quite sure whether we would not have been the chief losers in the long run.

We went up into the Nanda Devi basin, eight of us, seven climbers and one

not a climber, though through no fault of his own. There were four Americans, C. S. Houston, A. B. Emmons, Adams Carter, and W. F. Loomis; the four British were N. E. Odell, W. H. Tilman, Peter Lloyd, and myself. We set to work in that wonderful gorge, and I would like to say that, when going up there, it really seemed marvellous to me that Mr. Tilman and Mr. Shipton had been able to find a way up in 1934: a grand piece of work in itself.

We were a small party, travelling light, and travelling in the monsoon. We travelled in the monsoon because our summer holidays happened to coincide with it, and there was very little other time in which this particular party could have gone to the Himalaya. We came to Nanda Devi and then our Sherpas unfortunately went sick. We had six of them. One Sherpa paid one visit above Camp II, two Sherpas got to Camp II, and the rest did not get farther than the Base Camp or Camp I. We had altogether six camps on the mountain, so that I can say almost the whole of the work above Camp I, and the whole of the work above Camp II, was done by the seven British and Americans.

The final climb was made by Odell and Tilman, and nobody deserved it better than Tilman himself. He was a grand man: his first exploration had been in 1934, and he had done what Mr. Shipton, rather humorously I think, called the donkey work. We got to the top and it was a very gratifying thing because we felt that we were a small party, climbing cheaply and simply, climbing at quite the wrong part of the year, and climbing quite a decent bit of mountain. We hope it will be an encouragement to other small parties to tackle the same sort of mountain in the same way.

The CHAIRMAN: I will ask the Secretary to tell us something about the photo-theodolite. We are always at daggers-drawn, the Secretary and I, over this. I have always averred that it is absurdly heavy and cumbersome, especially the theodolite stand. I prefer light camera legs, wobbling in the wind, which can be carried in a rucksack. Now it seems to me, from what Shipton and Tilman have said, that if we can have a photo-theodolite of Leica type portability it will be an instrument which will give us the advantages of the too-heavy photo-theodolite, and we shall now be able to congratulate the designers on evolving something really suitable for use in the field. I ask Mr. Hinks to tell us something of the instrument.

Mr. HINKS: I am anxious to say something about the instrument which Mr. Shipton has dignified by the name of the Watts-Leica photo-theodolite; it is not so terrifying or so complicated an instrument as it sounds. It was in fact improvised here in the Society in the space of three days before the Mount Everest reconnaissance of 1935. We had an old 3-inch mountain theodolite which had been in the possession of the Society for about twenty years; we secured a second- or third-hand Leica camera for about £7 and had calibration marks put in, and had a cradle made to carry the camera on top of the theodolite, the whole idea being that the instrument should be as light as possible. To turn on the film for the next exposure you just take the camera out of its cradle, replacing it in its geometrical bearing without sensibly deranging the theodolite. It is what we used to call, in elementary wireless days, a "hook-up," but with a certain merit about it, as was proved in the Mount Everest region in 1935 and as Mr. Shipton proved around Nanda Devi in 1936. We are looking forward to having the instrument re-designed this year so that it may go out to the Himalaya again. It is hoped that in the course of time it will be improved without being made any heavier, and that it may be quite useful.

The CHAIRMAN: We have had a very delightful lecture this evening. I know the country fairly well. I was there in 1905 and in 1907, and again, for a short time, with Hugh Ruttledge and his wife in 1927.

What strikes me most is the speed with which Shipton moved. He always went with two Sherpas only. When I was in these parts thirty years ago no natives were accustomed to climbing above the snow, and as first-comers who go to any district must be careful not to offend the natives in any way, so as not to make it more difficult for those who follow them, we could not take natives high in those early days. I climbed with the two Brocherels of Courmayeur, the home of the great Italian guides who have covered themselves with honour in Europe, Asia, Africa, and America. There were just the three of us, and we used to go away for days at a time into the blue. Shipton reverts to the earlier practice: he goes off alone with two Sherpas, carrying everything on their own backs. It is impossible for any but the smallest parties to cover such an amount of ground.

In 1907, when I was beaten in the Rishi gorge, I had to go straight at it after climbing Trisul. I had one day. We climbed up the northern wall for nearly 3000 feet and could not see any way along. We saw that we could get along the south wall, but we had no time to try it. Even so I am exceedingly surprised at the success of Major Osmaston in getting delicate survey instruments undamaged along that route. I should think that Colonel Lewis was speaking with all sincerity when he said that the success of this expedition was probably in considerable part due to Shipton being with them, for he was able to show the way.

As to the ground he covered in the Ronti valley, I have looked that up in my notebook and I find I spelt the word *Rönti*, but when I got home I said to myself, "Now, how would the English pronounce that?" So I wrote it *Rinti* and, as Shipton has said, that is wrong.

I hope there will be an endeavour to preserve the name Nanda Ghunti, which means the Goddess Nanda in her bridal veil, Nanda being the bride of Shiva, whose abode is on Trisul. If you can keep Nanda Ghunti for the south peak and Ronti for the north peak I think it would be an admirable solution. Between those two peaks, Trisul, the Trident of Shiva, and Nanda Ghunti, the goddess in the bridal veil, there is a serpent 100 yards long who eats all who come near the bride and her bridal veil. And, that you may know it is so, I was told that at the mouth of the *nala* there is a pile of slippers belonging to the men the serpent has eaten.

I look forward to the publication of the new map of the Nanda Devi basin with the greatest interest, tinged with a slight anxiety that my own map of thirty years ago may turn out to be too many miles out for what remains of my reputation.

I ask you to express your appreciation of Shipton's interesting lecture in the usual manner.

THE GLACIERS AND MORPHOLOGY OF THE FRANZ JOSEF FJORD REGION OF NORTH-EAST GREENLAND

N. E. ODELL

Afternoon Meeting of the Society, 9 November 1936

Introduction

THE purpose of this paper is to describe some of the interesting features of the glaciers, and of the ice-free terrain, of North-East Greenland, which were observed during the Louise A. Boyd Expedition of 1933. The itinerary of the expedition, and other studies by several of its members, have already appeared in Miss Boyd's book, 'The Fiord Region of East Greenland,' published (1935) by the American Geographical Society. And elsewhere the present author, as geologist to the expedition, has described some of his activities and observations amongst the mountains and glaciers of the hinterland bordering the inland ice, which were omitted from Miss Boyd's book.[1] The geological structure of the region has been treated by the present writer elsewhere.[2]

One of the most important chapters in 'The Fiord Region of East Greenland' is that by Professor J. Harlen Bretz, entitled "Physiographic studies." In this is given an excellent summary of his investigations and conclusions regarding a number of aspects of the local physiography. While with these conclusions the present writer is very largely in agreement, there are some points regarding the geomorphology of the region in which he differs from Professor Bretz. Such points will be duly discussed herein, more particularly in Part II, following a general consideration in Part I of the glaciers and conditions of present glacierization of the region.[3]

Part I: The Glaciers of the Region and their Structure

Cliffed fronts and borders

A striking feature of the glaciers of the Franz Josef Fjord region, where they terminate on land and do not reach tidal water, is the cliffed character of their snouts (see Fig. 1). As opposed to the sloping terminal fronts of the majority of alpine glaciers of the temperate zone at the present time, most if not all of the glaciers of North-East Greenland end in vertical and often overhanging walls, that frequently prevent the traveller from gaining easy access to their upper surfaces. And not only the actual termini, but in

[1] N. E. Odell, "Franz Josef Fjord, and the Mystery Lakes District, North-East Greenland. Some discoveries during the Boyd Expedition, 1933," *Scottish Geographical Mag.*, 1937 (in course of publication).

[2] N. E. Odell, "The structure of the Franz Josef Fjord Region, North-East Greenland," *Medd. om Grønland* (in course of publication).

[3] It is very desirable that the distinction between the terms "glacierization" and "glaciation," long ago proposed by Wright and Priestley, should be adhered to: glacierization being the inundation of land by ice, and glaciation the erosive action exercised by land-ice upon the land over which it flows (Wright and Priestley, 'Glaciology,' p. 134).

many instances long stretches of the sides of the glaciers are cliffed and undercut in this way to a surprising degree, to form what is sometimes called a "Chinese Wall." The same characteristic has been reported of the glaciers of North-West Greenland by Chamberlin, Koch, and others.

The explanation of sloping snouts of glaciers is usually that they are in a receding condition, or one of equilibrium, while cliffed and overhanging fronts are generally attributed to forward activity and advance of the ice. Other factors may however be contributary in certain cases to steep borders of glaciers, such as re-radiated heat from the enclosed valley-walls,[1] erosion by early summer melt-water descending from the upper portions of the glacier,[2] or a combination of two or more of these processes. It would seem indeed that caution is necessary in applying the criterion of steepness for a state of advance. Bretz, in his chapter on "Physiographic studies," [3] is inclined to adopt T. C. Chamberlin's explanation for the cliffed glaciers of West Greenland: that the impinging of the sun's rays at low angles from all points of the compass in succession causes excessive melting on their margins. There would seem however to be definite limits to the application of this

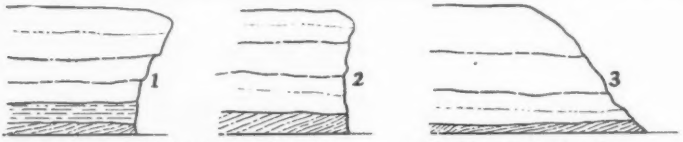


Fig. 1.

explanation in regions of such high relief as that of Franz Josef Fjord, where mountain walls in many cases intercept the direct rays of the sun.[4]

Temperature conditions

Although much in the way of precise measurements of the temperature conditions of the *névés* of alpine glaciers remains to be done, glaciological studies of recent years have established that the glaciers of temperate regions remain approximately at melting-point throughout their bulk. In general only in winter-time do the top layers of such glaciers drop below freezing-point through a depth not exceeding a few feet. The considerable quantity of melt-water issuing from many glaciers of the Alps and Norway in winter bears witness to this fact.

On the other hand it was shown by J. P. Koch and A. Wegener during their expedition to North-East Greenland in 1912–13 that the glaciers of high latitudes remain frozen to a considerable depth all the year round.

[1] For examples see N. E. Odell, "Observations on the rocks and glaciers of Mount Everest," *Geogr. J.* 66 (1925) 306.

[2] Cases from Alaskan glaciers are described by Louis E. Ray, "Some minor features of valley glaciers and valley glaciation," *Journ. Geology*, XLIII, 1935, 297.

[3] Bretz, in Louise A. Boyd, 'The Fiord Region of East Greenland,' p. 197.

[4] Cf. L. Koch, "Contributions to the glaciology of North Greenland," *Medd. om Grønland*, 65, p. 210, 1928.

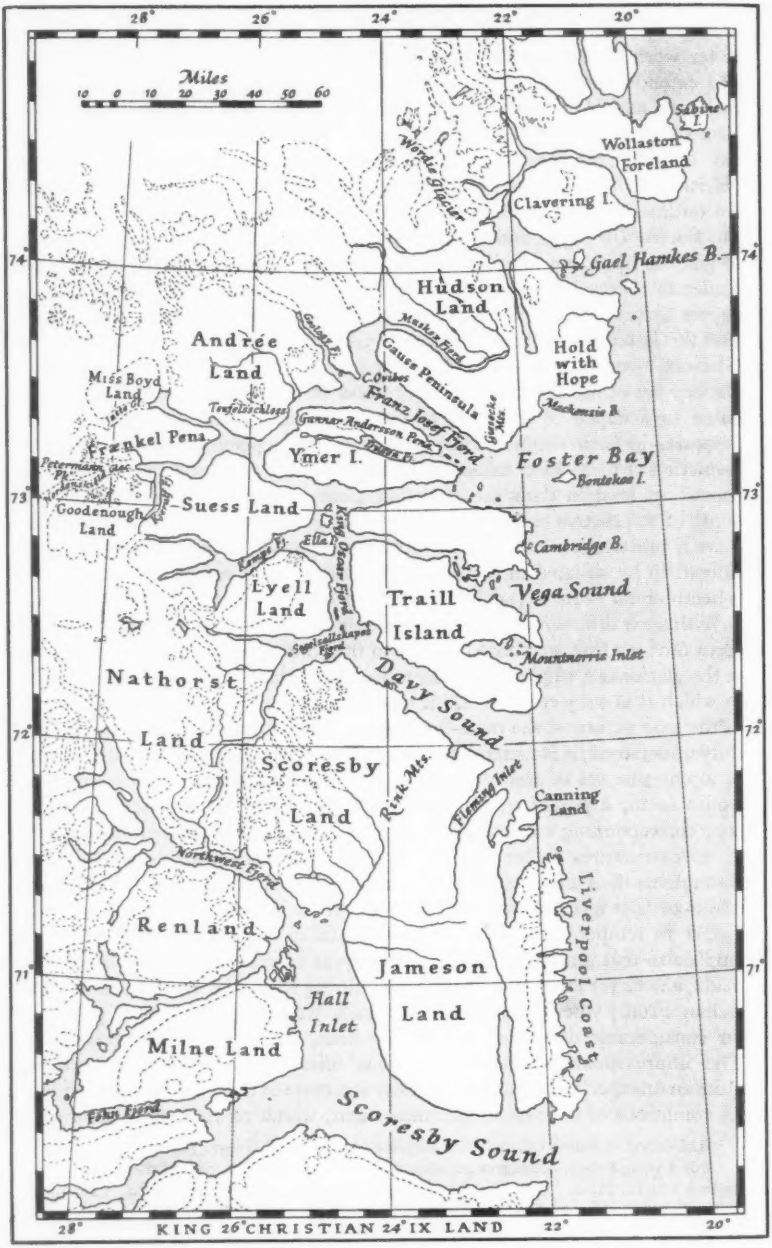
Later work by Wegener's Greenland Expedition of 1930–31 has amplified and extended our information on this point. But it is to Professors H. W. Ahlmann and H. N. Sverdrup, whose researches in Norway and in North-East Land have been pursued since 1923, that we owe perhaps as much as any one else for their comprehensive investigations upon the physics of glaciers and the factors contributing to their consolidation and wastage. An outline of those investigations was presented by Professor Ahlmann to this Society (in 1935), and on the same occasion an interesting classification of glaciers upon the basis of their temperature conditions was given.[1] The reader is referred to the original article, in addition to Ahlmann's earlier papers therein cited, for details of this classification; suffice it to say here that the latter, apart from Temperate Glaciers, includes two kinds of Polar Glaciers, namely High-Polar Glaciers and Sub-Polar Glaciers. Sub-polar glaciers are claimed to have in their areas of accumulation crystalline *névé* down to a depth of some 10 or 20 metres, and mean summer air temperatures in their neighbourhood being at melting-point or slightly below, formation of melt-water takes place. High-polar glaciers, on the other hand, consist, at least in their accumulation areas, of crystalline *névé* down to a depth of 200 metres or more. Even in summer the temperature is so low that there is practically no melting or formation of water. These glaciers are considered to be situated in districts where the mean summer air temperature is below about −10° C., such as the Inland Ice of Greenland and Antarctica.

With such differences in the physical character of the *névé* or ice, it would seem obvious that we should expect to find differences in the mode of flow of the glacier as a whole, according to the particular set of external conditions to which it is subjected. While it has to be admitted that there is much as to the true nature of the mass- and energy-transference involved that is not fully understood, it is generally recognized now that the aggregate movement of alpine glaciers of the temperate type simulates viscous flow.[2] And this would seem, *a posteriori*, to be in accordance with their general physical state corresponding with the melting-point of the ice,[3] whilst a preponderance of flow-structures rather than shear-structures is frequently in evidence throughout their mass as witness of this. We cannot however be too conscious of how ignorant we still are as to the movements in detail of *névé* or glacier in temperate or polar regions. Nothing has done more perhaps to emphasize that ignorance in regard to Alpine glaciers than the observations made, and as yet incompletely reported, during the Great War on the Austro-Italian Front, where galleries and tunnels were dug for tactical purposes for considerable distances beneath the firns, and along the bergschrunds. The unprecedented opportunities thus offered for observation revealed quite an unexpected complexity of inner structure of these features, dependent on conditions of deposition and movement, which refutes rather than con-

[1] Ahlmann, "Contribution to the physics of glaciers," *Geogr. J.* 86 (1935) 97–113.

[2] For a recent comprehensive presentation of the viscous or plastic theory of glacier motion see H. Hess, "Das Eis der Erde," *Handbuch der Geophysik*, Bd. VII, 1933; or English summary and comments by O. D. von Engeln, in *Science*, 80, p. 401, 1934; 81, p. 459, 1935.

[3] Viscosity decreases with rise of temperature (cf. Wright and Priestley, 'Glaciology,' p. 478).



East Greenland

firms many standard theories of glacial flow, and strongly suggests caution in such additional classical questions as those relating to strong floor-erosion within firn-basins and cirques. The latter problem will be returned to later in Part II.[1]

With regard to polar glaciers, it is the sub-polar type that has up to now received the greatest attention from the point of view of their physical constitution. The glaciers of North-East Land and Spitsbergen, where climatic situation and summer temperatures allow of much melting, have been shown by Ahlmann to conform to this type. The high-polar type, on the other hand, has as yet been the subject of little physical research. The classical studies of T. C. Chamberlin in North-West Greenland long ago showed that the glaciers in that region have a great many features which differentiate them from those of Alpine type. Indeed he demonstrated that the glaciers of Disko Island at lat. 70° on the west coast have many characteristics more closely resembling those of temperate climates than they do the ice-streams of such a neighbourhood as Inglefield Gulf at lat. 77°5.[2] From Lauge Koch's comprehensive geographical investigations of the glaciers of northern Greenland, we can gather that he is of the opinion that sundry features of them, as for instance their vertical fronts, must be attributed to the low temperatures to which they are subjected throughout the year.[3]

Characteristics of high-polar type of N.-E. Greenland glaciers

It would seem that not merely in the main body of the *névé* of the Inland Ice, but also in the marginal glaciers, which serve as outlets to the great carapace, are to be found temperature conditions so low that little or no melting can take place. Nothing is more striking, as is described elsewhere,[4] in the case of the Gregory, Trident, and other glaciers, than the paucity of melt-water given off by them. There was no drainage of highly silty water from a main tunnel in the terminal front as in the usual Alpine glacier, but small streams only issuing from the foot of the snout, and of relatively clear water. Sometimes no sub-glacial streams at all were to be seen. The greater part of melt-water, if not all, came from surface drainage, and either cascaded down the terminal front or by way of the borders of the glacier. During the midnight hours of lower northern inclination of the sun, this drainage shrank to a mere trickle. We may conclude then that these marginal glaciers from the Inland Ice are frozen even in summer throughout their mass. What then is their mode of flow?

All the glaciers terminating upon land which we saw in this region have this in common, that they are constituted of an upper portion of relatively clear moraineless ice, and a lower part which is heavily charged with morainic material. One is struck at once by this generally prevailing distribution of englacial matter within the bulk of the glaciers, and many figures in Miss Boyd's book, as well as photographs here reproduced,

[1] R. Klebelsberg, 1920, "Glazialgeologische Erfahrungen aus Gletcherstollen," *Zeitschrift für Gletscherkunde*, XI; and review in *Geogr. J.* 58 (1921) 72.

[2] T. C. Chamberlin, 1894, "Glacial studies in Greenland II," *Journ. Geol.*, II, p. 788.

[3] Lauge Koch, 1928, *op. cit.*, p. 210.

[4] N. E. Odell, 1937, *op. cit.*

clearly illustrate the fact. One notices also that in numerous cases the upper clearer half overhangs the débris-choked basal portion, as if the movement forward of the former were greater than the latter. This feature is especially noticeable at the snout, as would be expected, though it is often to be seen as well in the adjoining borders for some distance upstream from the terminus, where actual calving can be seen to be taking place. There seems to be no doubt then that the upper layers are moving differentially from the lower ones, and that they are in many cases being thrust forward as a unit or units over the more resistant basal layers. That this differential movement exists is fully borne out by the condition of the basal layers, which in every case where close examination could be made display thrust-planes and drag-folds, with in some instances associated fault-breccia.[1] Repeated thrusting in some examples seen gives rise to imbrication of thrust upon thrust ("schuppen Struktur"). In the remarkably corresponding examples from the Inglefield Gulf region of North-West Greenland Chamberlin has described this same phenomenon, and has declared this disposition to overhang as "doubtless to be attributed partly to the more rapid movement of the upper layers of ice and partly to the more rapid melting of the discoloured ice below, the two agencies acting jointly." And he adds, "the verticality is not only characteristic of the end of the glacier but of the sides."[2] Whether or not the additional heat absorption, and therefore melting at their outcrop, of the moraine- and silt-laden layers actually accounts for much of this overhang is from observations of my own rather questionable; but what should not be forgotten is the increased viscosity (reduced liquidity) that this débris-charged basal portion of the glacier must acquire in virtue of its solid content.[3] This may well result, at the low prevailing temperatures, in a material of such rigidity that it yields more easily by fracture than folding alone, and many examples of glaciers in the region under review seem to confirm the existence of this property.[4] But that it is not the moraine-laden ice only that moves by shearing, and accompanying drag-folding, can be seen from such a case as Moraineless Glacier in the Gregory Valley.[5] Furthermore from the observations of J. P. Koch and A. Wegener in Dove Bay and Queen Louise Land, farther north (lat. 76°5) in North-East Greenland, we gather that they found abundant evidence of movement by fracture and shear, rather than according to the laws of viscous flow, both for the main body of the Inland Ice as well as its dependencies.[6]

Wall-sided glaciers

Mention should also be made of R. E. Priestley's type of "Wall-sided Glaciers," defined by him from Antarctic observation as streams of ice,

[1] See Bretz, *op. cit.*, Fig. 269.

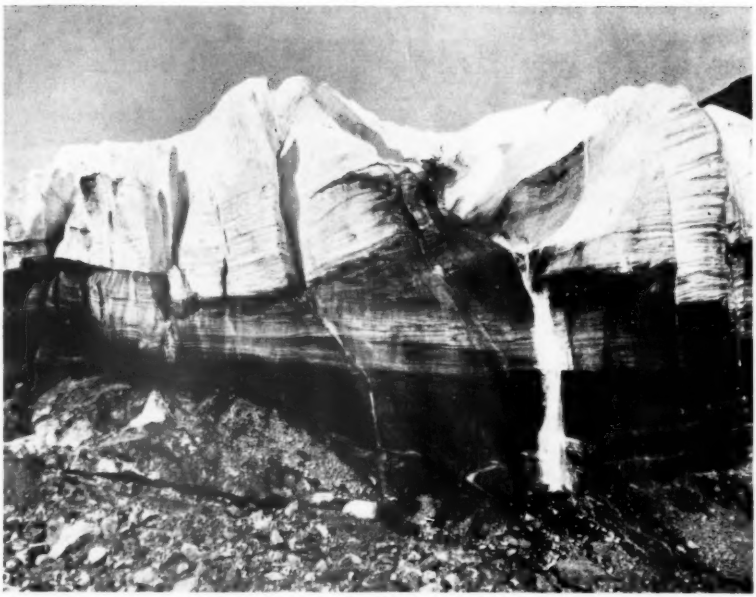
[2] T. C. Chamberlin, 1895, "Glacial studies in Greenland VI," *Journ. Geol.*, III, p. 565.

[3] Wright and Priestley, *op. cit.*, p. 479; also H. Hess, 'Die Gletscher,' p. 19.

[4] The question of basal shear in glaciers has been recently discussed by R. T. Chamberlin, "Glacier movement as typical rock deformation," *Journ. Geol.*, 44, p. 102, 1936.

[5] Cf. Bretz, *op. cit.*, p. 182, and accompanying Fig. 271.

[6] J. P. Koch and A. Wegener, 1930, *Medd. om Gronland*, 75, Pt. I, pp. 243 *et seq.*



Terminal front of Louise Glacier. Shearing of upper layers over moraine-laden lower layers

Trident Glacier. Repeated faulting and drag-folding in basal layer

Nathorst Peak (right), from the junction of the Gregory and Nathorst Glaciers

originating in, and fed by, upland ice of any description, and flowing down towards sea-level unconfined by any marked valley wall. He considered that "they may represent a comparatively recent remnant left by the irregular breaking back of a sheet of Highland Ice, or the thin margin of the Continental Ice; or it may be a recent local extension of either of the above ice-forms due to a recent local increase of precipitation." [1] Priestley's figures show examples of "wall-sided" distributaries that are considered to be due respectively to local advance and retreat of the Highland Ice.

A number of instances of these wall-sided glaciers, depending from portions of highland and other mountain ice, were seen in the inner parts of the Franz Josef Fjord region. Of these Avalanche Glacier, on the south side of the Gregory Valley, might be held to exemplify Priestley's "advancing distributary" (cf. his Fig. 65), and that of a small cliffed tongue on the north-east flank of Nathorst Peak to typify his "retreating distributary" (cf. his Fig. 66). Does this represent the actual state of affairs in each case? From conditions of glacierization generally in the district concerned there seems to be neither advance nor retreat taking place at the present time, but the glaciers appear rather to be in a state of equilibrium. This suggests that their alimentation is at present fairly constant. Moreover the two localities cited above are within 10 miles of each other, and it is unlikely that conditions of precipitation are so different as to give increased alimentation and advance in one case, and decreased supply and retreat in the other, as required by Priestley's theory. In the writer's opinion it rather appears that, as in the case of the valley glaciers of this region, the wall-sided character of these upland ice-masses is a function of their physical condition, namely their frozen state, and their movement by shearing and overthrusting. That they so fastly adhere to the steep mountain shelves on which they are often situated and do not slide into the valley may well be on account of their basal layers being frozen to the rock.[2] A remarkable example of this adherence, that truly amazed Professor Bretz and the writer, was a glacier that descended obliquely on a mountain-shelf on the north-east side of the lower Mystery Lake. Along a front of about a quarter of a mile this glacier discharges by avalanching over the edge of the shelf down to the lake. But at its extreme lower end it descends the mountain wall, and its snout succeeds in clinging to the wall for about 1500 feet and not breaking away.[3] Another astonishing instance seen was the cascading glacier on the south side of the upper Jaette Glacier, to be referred to later on another account, which descends from an upland *névé* and retains its continuity on a precipitous drop of 2000 feet to the main glacier.

It may be added that Lauge Koch has given it as his opinion that wall-sided glaciers are not common in Greenland, and he knows of no instances in northern Greenland where they may be attributed to a recent local increase of precipitation. He considers the non-existence of typical wall-sided glaciers as due to the fact that the climate has long remained unchanged.

[1] Wright and Priestley, *op. cit.*, p. 153.

[2] For this latter idea as to the probability of such glaciers being frozen to their rock bed I am indebted to Dr. Fritz Loewe.

[3] For an illustration of this glacier see Bretz, *op. cit.*, Fig. 325.

In the few cases where cliffed upland glaciers do occur he is inclined to think that they indicate that the highland ice is either receding rapidly or in rapid advance.[1]

It is of interest in connection with the question of advance and recession that a few years ago Koch reported that in the coastal district of these latitudes he found the glaciers on the south side of Dusén Fjord, Ymer Island, mostly extending down to sea-level, but that they were in a dead condition and completely covered with moraine. The only other place he had seen with similar conditions were glaciers in the western fjords of Disko Island on the west coast of Greenland. He noted also that the snow-line on Ymer Island was surprisingly high—at about 1200 metres (say 3900 feet) on the plateaux.[2] In contrast with the latter figure J. M. Wordie reported the snow-line in 1926 as high as 5000 feet, and I am prepared to regard it under summer conditions at the present time in the mountains of Fraenkel Peninsula and Miss Boyd Land as even higher, at approximately 6000 feet.

It may be added that in the Angmagssalik district in South-East Greenland Milthers has found the glaciers over a period of years in a state of retreat.[3]

Discordant junctions in glaciers

During a first exploration of Miss Boyd Land, I noticed on Louise Glacier a striking feature that I have no recollection of having seen before either in the glaciers of temperate regions or on those of Spitsbergen. Louise Glacier is fed by two main ice streams descending from what we tentatively termed the North and South Cirques and meeting at an oblique angle. Instead of these coalescing to form a level junction of normal accordant type, they were found to be markedly discordant, the margin of the North Cirque Glacier forming a steep glacis rising about 40 feet in height above the level of the South Cirque Glacier (see Fig. 2). This glacis, or sloping wall, commencing at an altitude of rather over 3500 feet at the foot of a dividing mountain nunatak, ran on downstream for perhaps a mile until the ice of the two glaciers became more or less accordantly merged. It appeared as if the North Cirque Glacier may at one time have advanced sufficiently to have overridden the ice of the South Cirque Glacier, but that under conditions of recession it has withdrawn and now shears along the margin of the latter. Bretz has recorded from observations in the neighbourhood of the lower part of Louise Glacier that there is evidence of recent retreat.[4] And, if such is the case, it is of some significance that it should be associated with a cliffed front, which is usually considered a sign of advance.

Moreover another interesting discordant junction was to be seen upon this same South Cirque Glacier where on its extreme eastern side a minor affluent was being carried upon the back of the larger ice-stream, until at an altitude

[1] L. Koch, 1928, *op. cit.*, p. 343.

[2] L. Koch, 1930, *Medd. om Grønland*, 74, p. 393.

[3] *Vide* Gabel-Jorgensen, 1935, "Dr. Knud Rasmussen's contribution to the exploration of S.-E. Greenland, 1931–33," *Geogr. J.* 86 (1935) 40–53.

[4] Bretz, *op. cit.*, p. 183. On p. 179 Bretz makes the surprising remark that Louise Glacier "is wholly in the zone of wastage." Since however it debouches from three very considerable cirques, it clearly has a very ample area of accumulation.

of about 3280 feet (1000 metres) it wasted away. The lateral and basal moraines of this small affluent then coalesced, and so to speak swung round to join the lateral moraine of the main ice-stream. This latter unusual manoeuvre is incidentally referred to by Bretz, but its significance would appear to have escaped him.[1] There can be small doubt that this tendency for the component ice-streams of a compound glacier to override one another, according to their relative bulk, and not mingle at an accordant level of surface, is a characteristic of which little if anything has heretofore been recorded. One grows indeed so accustomed to the almost universal obedience of glaciers to Penck's law of adjustment of cross-sections that variants from it come as a surprise. The remarkable cascading glacier on the Fraenkel Peninsula side of the Jaette Glacier (referred to above) is another example of an overriding tributary. Not only is it astonishing that it should remain apparently frozen to its steep wall during a descent of 2000 feet, but that on reaching the great Jaette ice-stream it should move along, steeply

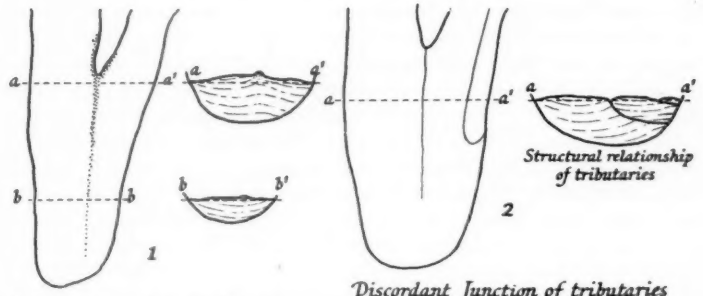


Fig. 2.

margined, on top of the latter, and finally after a mile or so deploy to form its own independent cliffed and lobate snout. Instead of mingling and fusing with the main stream this tributary refuses any semblance of union, and preserves its discordant relationship to the end.

Other cases could be cited, and there is no doubt that many further examples of compound discordant glaciers could be found in the region. The writer is of the opinion that there is sufficient evidence to suggest that this feature of discordance, not known as far as he is aware in ordinary alpine glaciers of the temperate zone, must be a characteristic of those of high latitudes. The view is put forward that it may, at least in part, be brought about by the frozen state of polar glaciers, other peculiarities of which have been already discussed. Now it cannot be claimed that all junctions of tributaries with main trunk glaciers, which were seen in North-East Greenland, displayed this discordant and overriding relationship, as far as one

[1] Bretz, *op. cit.*, p. 179.

could judge. That is to say, discordance was not always visible as a difference in level or relief at the surface of the glacier, nor even by the development of blue-band structure in the ice, but this does not deny the probability of the preservation of the component ice-streams at a discordant junction within the hidden mass of the glacier, especially if they are moving at different velocities. If compound or composite polar glaciers remain frozen throughout their life-history, their component ice-streams, having different velocities, will tend to remain unfused and uncemented, since it is known that ice at low temperatures is not subject to the phenomenon of regelation [1]; more strictly stated, the vapour-pressure of ice varies directly with temperature, and is very slight indeed in ice at low temperatures. Moreover there is strong presumptive evidence that many of the high-polar glaciers of North-East Greenland do preserve the identity of their component tributaries, for one reason or another, as is to be seen in the lower parts of Trident and Louise Glaciers especially. The pronounced longitudinal furrows running for many miles up and down these glaciers, to which reference has more than once been made, would seem to mark the preservation of the several units, which descend from their respective feeding-grounds in the uppermost reaches of the surrounding cirques. Their adjacent margins, marked often by lines of more or less moraine, suffer pronounced ablation in comparison with the more compact banks or ridges of ice, and the resultant channels become no doubt emphasized in many cases by melt-water. That the furrows cannot wholly be the work of melt-water drainage is clear from the fact that in following the changes in grade of the glacier the channels retain approximately the same cross-section. That the furrows often coincide with lines of moraine or silt which can be traced upstream to dividing spurs or nunataks is strongly suggestive of their origin along lines of discordance in the glacier as a whole, which are the result of ice-streams of varying velocity.

It seems probable that under favourable conditions, climatic and otherwise, all polar glaciers (as opposed to *névés*), and especially sub-polar ones, may have their temperature in parts sufficiently raised by percolating melt-water to bring about fusion and regelation. There can be no doubt, for instance, that where a component of a composite glacier has become crevassed during the descent of an icefall, or even cracked by movement over irregularities in its bed sufficiently to allow of the admission of quantities of melt-water, its temperature must become raised thereby. Such a condition might well be brought about even in parts of high-polar regions where geographical aspect or local climate is sufficiently favourable. But in the sub-arctic glaciers, and in those of such a specially genial position of high latitude as Spitsbergen, it is likely that the physical state of the ice, at any rate in their upper layers in summer, is always in the neighbourhood of, and mostly above, melting-point, when the phenomena of discordance would be an impossibility, unless possibly there is high differential velocity between the ice-streams. A. Hamberg concluded that it is possible or probable that Spitsbergen glaciers, at least in parts, retain a negative temperature (Centi-

[1] *I.e.* "regelation" in the original sense of the word: the adherence of two pieces of ice at melting temperature; and not in the spurious significance sometimes more recently given it of alternate freeze and thaw in arctic soils.

grade) even in summer.[1] But, as Ahlmann points out, no direct observations have as yet been made of the temperature of glacier-ice in Spitsbergen which might confirm or disprove this, though there are facts which suggest that these glaciers, at any rate in their *névé* areas, remain frozen to a considerable depth even in the summer.[2] In the case of the "Chinese Wall" fronts of glaciers described by Garwood and Gregory,[3] there was clear evidence that at least one of them, namely that of Booming Glacier, was due to local advance. Nearby was Baldhead Glacier, with a tapering snout, which was considered to be in state of retreat. Several other glaciers were seen that terminated in vertical or overhanging faces and all were considered by Garwood and Gregory to be advancing. The nature of their advance and movement was attributed, in the lower débris-laden portion, to upward thrust along shear-planes, while the upper cleared ice-layers moved by a simple flow corresponding with Swiss glaciers.

These observations therefore all seem to accord with the view that in Spitsbergen many glacier-tongues are in a partly frozen and partly melting condition, and my own observations in that country are in agreement. That the upper layers of few remain during summer below melting-point would explain the almost complete absence of discordant junctions on any compound glaciers that have been described. The one instance known to the writer is the tributary of Booming Glacier, mentioned by Garwood and Gregory, which in spite of reduction in the main stream continued to advance and spread out over that by which, it is supposed, it was once dammed back and absorbed.[4] But no reasons are advanced for such an unusual relationship in this isolated case. It should be added that, from observations in 1934 on Isachsen's Plateau, H. N. Sverdrup has concluded that in West Spitsbergen melting at the surface of firns in general is so great that the heat set free, as water percolates down and freezes (latent heat), is more than sufficient for raising the temperature to freezing-point at all depths. If this is so with the firns, how much more must it be in the case of their diffluent glaciers, and how few are the chances of their showing high-polar characteristics.[5]

Three further arctic examples of glacial overriding recorded from Greenland have been kindly brought to my attention by Dr. Loewe. One was observed many years ago by A. Kornerup at the Dalagers Nunataks in lat. 62°40, south of Sermilik Fjord, near Godthaab, on the west coast. His sketches show clearly that portions of the Inland Ice, after streaming through the line of nunataks, assume a discordant relationship to the ice that has passed round their flank and which lies at a lower level. This discordance is plainly shown by the ground moraine that is brought to the surface, and which

[1] A. Hamberg, 1932, "Struktur und Bewegungsvorgänge im Gletschereis, etc.," *Naturwiss.*, Bd. I, Abt. III, Stockholm.

[2] Hans W. von Ahlmann, 1933, "Scientific results of the Swedish-Norwegian Arctic Expedition in the summer of 1931," *Geografiska Ann.*, 1933, pp. 2–3, 202.

[3] Garwood and Gregory, 1898, "Contributions to the glacial geology of Spitsbergen," *Quar. Journ. Geol. Soc.*, liv.

[4] Garwood and Gregory, *op. cit.*, p. 208.

[5] Sverdrup, 1935, "Scientific results of Norwegian Swedish Spitsbergen Expedition in 1934," Pt. III, *Geografiska Ann.*, XVII, p. 88.

lies in horse-shoe fashion, or arcuate outline, round the farthest extent of the overriding ice.[1] Kornerup however, quoted by Suess, considered that the ground moraine is merely carried up from the bottom to the surface by reason of the restriction of the ice-stream between the nunataks and an action similar to that of a "swirl-colk" in a river: he draws a parallel from a breached dyke on the Danube, where broken blocks were spread out in a horse-shoe curve below the breach.[2] A rather similar case is described and illustrated by J. P. Koch and A. Wegener from North-East Greenland during the Denmark Expedition of 1906–08. A diffluent of the Inland Ice, in making its way between Ymer Nunatak and Queen Louise Land, for unexplained reasons suddenly overrides the main ice, and throws up a great curve of terminate moraine of horse-shoe outline.[3] The third example is in the near vicinity of that described by Koch and Wegener, namely farther south-east towards Cape Bellevue on Queen Louise Land. In fact V. Laub, of the Alabama Expedition under Ejnar Mikkelsen in 1909–12, considered that the "belt of stone and rubble" which he discovered was a continuation of Koch's horse-shoe moraine. Its real nature and relationship is however less well defined.[4] It may be mentioned, in addition, that an overriding relationship of tributary and main ice-stream, as shown by upthrown moraine, has been cited by Hess in the Muir Glacier of Alaska, as well as in the alpine example of the Grenz Glacier at its junction with the Gorner. Differences in velocity of the main glacier and its tributary are here suggested in explanation.[5]

Finally, the Dutch mountaineer, Ph. C. Visser, has recently described some remarkable examples of overriding and overthrust amongst the glaciers of the Karakoram Mountains. In the Nubra and Shyok district he has observed a number of glaciers whose tributaries, instead of meeting the trunk stream in the ordinary way to make accordant junctions, mount up on the surface of the main glacier and travel onwards to form their own independent snouts and horse-shoe terminal moraines. Moreover he has noted the unusual number of instances of cliffed borders and terminal faces to these glaciers, which cannot be attributed only to re-radiated heat from enclosing mountain-walls, but which in his opinion bear evidence of overthrusting of layer upon layer, in the same way as has been shown above to be so prevalent in polar glaciers. In two important articles [6] Visser has cited the evidence for the view that these Karakoram glaciers display a marked tendency for differential movement within their mass, and for independence of velocity of component ice-streams in the case of compound glaciers. Incidentally, in an interesting and ingenious way he attributes the formation of the lines of great

[1] A. Kornerup, 1879, "Geologiske Fagttagelser fra Vestkysten af Grønland," *Medd. om Grønland*, I, Pl. V, Fig. B′ and B″.

[2] Suess, 'Face of the Earth,' vol. 2, pp. 343, 344.

[3] J. P. Koch and A. Wegener, 1917, "Die glaciologischen Beobachtungen der Danmark-Expedition," *Medd. om Grønland*, XLVI, p. 42, Figs. 33, 46, 47, Pl. III.

[4] Vilkelm Laub, 1922, Report II, Alabama Expedition, *Medd. om Grønland*, LII, pp. 166–7, Fig. 69, Pl. I.

[5] H. Hess, 'Die Gletscher,' pp. 205–6.

[6] Visser, 1932, "Gletscherüberschiebungen im Nubra- und Shyoch-Gebiet des Karakorum," *Zeit. f. Gletscherk.*, XX; 1935, "Gletscherbeobachtungen im Karakorum. Scherflächen und Gletscherüberschiebungen," *ibid.*, XXII.

Louise Glacier showing discordant glacier junction

Louise Glacier from west. Faintly discordant junctions of tributary glaciers and accordant summit levels

Cascading glacier. Outflow tributary to, but discordant upon, ice of Jaette Glacier

Trident Glacier. Longitudinal furrows mark junctions of confluent tributaries

ice pyramids of these glaciers as ultimately due to the splitting up into detached blocks of a smaller tributary on the back of a larger and faster-moving glacier, the ice-blocks eventually becoming reduced to isolated pyramids and pinnacles by the processes of ablation.

It is the difference in velocity of the component streams of these glaciers that Visser has very plausibly emphasized as the main cause of the discordances seen. But may there not be other factors operative, such as the physical character of the ice, to give the remarkable effects observed? It would seem certain indeed that the greater part of the ice of these Karakoram glaciers must in summer be at melting-point, and not in a frozen condition, as in the case of corresponding phenomena amongst polar glaciers. No temperature observations were made by Visser, and consequently nothing is known as to the physical condition of the ice-streams he observed. We cannot be sure that portions at least of the latter are not still frozen even in the lower parts of their courses, and that this factor combined with marked difference in velocity is not responsible for the unusual relationships seen. It may be that in some cases melt-water aids differential movement between portions of the ice-masses.

In a recent paper to this Society entitled "The Study of Threatening Glaciers," [1] which treats primarily of sudden and destructive advance in glaciers, Professor Mason, from observations on the Shyok glaciers, has given it as his view that the fortuitous overloading of the *névé* basin gives rise to a superficial slide forward of a portion of the ice, which may travel on upon shear-planes on the back of the main glacier as far as, and in some cases beyond, the snout. He considers moreover that the lines of massed ice-pinnacles, which are a feature of these glaciers, represent a wasted and dissected remnant of such overriding ice-streams, and it is perhaps significant that these ice-pinnacles often bear evidence of what were taken to be shear-planes which can be traced in adjacent pinnacles. Closely corresponding phenomena of activity have been recorded from the Andes of Argentina, particularly in connection with the resulting flood of the Mendoza River in January 1934 [2]; and in reviewing the events leading up to the latter disaster, Dr. Robert Helbling has given it as his opinion that a superimposed sliding ice-cover of the Nevado Glacier, moving forward on shear-planes parallel with the bed, and lubricated by ample quantities of melt-water, was the particular glacial mechanism which led to the ice-dam and flood.[3]

Elsewhere in the Himalaya, and notably in some of the glaciers descending on the northern side of Everest, the writer has observed what he regarded as evidence of shearing due to differential flow in parts of a glacier. On the East Rongbuk Glacier it seemed that such a process was the cause of the development of blue-banding along a longitudinal zone that in the lower parts of the glacier gave rise to the feature known as the "Trough." Unequal ablation and wastage of the sides of the latter brought about the formation of projecting buttresses which eventually became the giant ice-pinnacles

[1] *Geogr. J.* 85 (1935) 24–41.
[2] *Geogr. J.* 84 (1934) 321–26.
[3] *Geogr. J.* 85 (1935) 41–49.

with which that glacier was so notably adorned.[1] It was noticed however that in the case of the main Rongbuk Glacier there were lines of pinnacles that, as far as could be seen, were unassociated with such a prime cause as a Trough. Some of these seemed to lie along a superficial band of ice that may conceivably be just such an overriding tributary as Visser has recorded in the Karakoram ranges. If its basement-ice were moving faster or irregularly there would then be a tendency, as he has suggested, for detachment into blocks of the overlying ice-stream, particularly in its lower thinner reaches, and the eventual carving of the blocks by the processes of ablation and melting into pinnacles and pyramids. It is significant that these rows of pinnacles of the Rongbuk Glacier were observed to be bordered by lines of medial moraine, which clearly marked out individual elements of the main ice-stream. But whatever the main factor may be in facilitating such differential movement in these particular glaciers melt-water plays no part at all in the mechanism, since practically speaking there is none throughout this district of the Himalaya. Indeed the glaciers of the latter district would seem to fall by their physical conditions into the category of sub-polar, if not high-polar, type.

There are however many features of these high-altitude glaciers, and their secondary ice-structures, which require further study for full understanding, and it would seem that no more profitable approach to that study in the future could be hoped for than along the lines already embarked upon with such promise in polar regions by Professor Hans Ahlmann. He has indeed given it as his opinion, in the paper already cited, that these physico-glaciological investigations on glaciers at the highest altitudes are now the most important contributions to glaciology.[2] It is the opinion of the writer that no opportunity should be missed on the part of climbing and exploring parties in the higher Himalaya to advance this important and fascinating work, by careful record of features seen and more particularly by instrumental observation of the relatively simple kind required.

Conclusion

Summarizing, therefore, it can be said with some confidence that the glaciers of North-East Greenland, whether debouching from the Inland Ice or from local mountain *névés*, exhibit phenomena indicative of their being, even in summer, at a temperature below freezing-point throughout their mass: only their superficial layers ever approximate to melting-point during periods of appropriate exterior summer temperatures.

In consequence of this frozen condition, and the greater rigidity of the ice, the glaciers move more by fracture and differential shear of their parts, than by inter-granular adjustment which in the aggregate approximates to the laws of viscous flow.

The prevailing characteristics relevant to their frozen state are: the absence of basal melt-water; the repeated imbricate faults, shear-plans, and drag-folds that are to be seen particularly in their basal layers; the vertical or over-

[1] N. E. Odell, *Geogr. J.* 66 (1925) 307.
[2] Ahlmann, 1935, *op. cit.*, p. 113.

hanging terminal and side walls; the discordant and overriding junctions in composite glaciers; and the adherence of many glaciers to very steep mountain sides.

These general considerations lend support to, and place the glaciers of North-East Greenland in the high-polar type of, Ahlmann's geophysical classification. It is probable moreover that certain glaciers of the temperate zone, provided that the high-altitude and therefore temperature-conditions are adequate, conform to either the high-polar or the sub-polar division of that classification.

(*To be continued*)

THE MEDICAL AND PHYSIOLOGICAL ASPECTS OF THE MOUNT EVEREST EXPEDITIONS

DR. C. B. WARREN

Afternoon Meeting of the Society, 10 May 1937

Introduction

THE climbing of Mount Everest calls forth physiological adjustments in the human body which are of great interest for the practical bearing which they have upon the success or failure of the venture. It is coming to be realized that the climbing of the mountain is almost as much a physiological problem as a mountaineering feat. Does deterioration in the physical condition set in when a certain altitude has been reached, despite the fact that acclimatization may still be going on? Is it possible to climb to 29,002 feet without using oxygen? These are problems which concern particularly the ascent of a high mountain. But perhaps it is worth remembering that the study of high-altitude physiology is beginning to have other practical applications in these days of aeroplanes and ever-increasing travel by air.

Since the main object of the expedition to Mount Everest in 1936 was to climb the mountain and no provision was made for scientific work to be done as a side line, only very simple observations could be made. These nevertheless may be worth recording since it is seldom that opportunities for collecting data at altitudes over 20,000 feet present themselves.

Mountain-sickness

It has long been known that people may be overcome by unpleasant symptoms on going rapidly to a great altitude. The malady is known as mountain-sickness. A person suffering from mountain-sickness complains of a variety of symptoms, some of the commoner of which are difficulty with the breathing, giddiness, headache, and a feeling of nausea which may end in vomiting. And many a mountaineer must at some period of his career have fallen a victim to this bogey of the sport. The condition is due to lack of oxygen as a result of breathing the rarefied atmosphere at high altitudes. It is often acute in onset, and affects only those who ascend rapidly before they have had time to get used to the heights. Thus speed of ascent and lack of acclimatization appear to be the essential factors for its production, though severe exercise will often precipitate the attack. The acclimatized person does not suffer from the acute form of mountain-sickness, though on going higher than the altitude to which he is acclimatized he may feel the effects in other ways.

It was during the earlier stages of the march to Mount Everest that acute mountain-sickness was met with. These marches brought us rapidly and steeply from the plains of India on to the high Tibetan tableland and involved an ascent of 16,000 feet within the first 70 miles. During the reconnaissance in 1935 we all suffered more or less severely from mountain-sickness on reaching Tangu at 12,000 feet, and again two or three days later when crossing the Kongra La. But in 1936 these early stages were taken more slowly, with the result that after a week's stay in the bungalow at Tangu the party went

over the pass two days later without serious consequences. Last year however the one time in the course of the expedition at which acute mountain-sickness with vomiting did occur was at Tangu on the outward journey. On that occasion the symptoms consisted of severe headache with dislike of the light, nausea and vomiting, and came on a short time after Smythe's return from a climb which he had done near the bungalow. Once the pass is crossed the route to the mountain runs for some 200 miles through comparatively level country, but all the time at altitudes greater than 13,000 feet. Throughout this part of the journey there is thus plenty of time for acclimatization to take place. Long before we had reached the Base Camp at 16,600 feet we had ceased to be breathless on the slightest exertion, and our headaches had passed away. Indeed we arrived at the Base Camp in high spirits and feeling as well as at sea-level.

Alterations in the breathing and the respiratory system

One of the most obvious changes associated with life at high altitudes is the difficulty with the breathing. This is most marked when the ascent has been rapid and acclimatization has not occurred; and still more so I think in those who are not accustomed to making mountain ascents. In 1936 most of us noticed breathlessness for the first time on reaching Tangu at 12,800 feet, and this persisted during the crossing of the 16,000-foot Kongra La and for several days thereafter. But in the course of the march to the mountain we became so well acclimatized that no discomfort with the breathing was noticeable at the Base Camp at 16,600 feet except when taking fairly strenuous exercise.

The nature of the difficulty with the breathing requires consideration. There was no marked alteration in the *rate* of respiration when at rest, but on the slightest exertion it increased out of all proportion to the amount of exercise taken. Then from time to time one would have to make a forced expiration followed by a long deep inspiration in order to get enough oxygen. Except during exercise there was no obvious alteration in the *depth* of the respiratory movements, though perhaps experiments with a spirometer might have detected a change. Alteration in the respiratory rhythm known as "Cheyne-Stokes" breathing was frequently observed during sleep. The altitudes at which this change of rhythm appeared were extremely variable even in the same individual. In one person it was present once at 9000 feet and again later at 21,200 feet. Illness often seems to predispose to it. Wakefulness at night time is sometimes occasioned by the breathing at high altitudes, particularly on going up to a new camp for the first time. Soon after getting off to sleep one wakes up suddenly with a slight feeling of suffocation and has to take one or two long deep breaths in order to get relief. The explanation of this is that during sleep the breathing becomes shallow and the lungs are not properly ventilated. As a result the carbon dioxide which is being formed in the body all the time cannot be got rid of in the breath and it therefore accumulates in the blood. If carbon dioxide accumulates in the blood and in the lungs the breathing is powerfully stimulated and there is a feeling of suffocation. By placing a high pillow beneath the shoulders at night the weight of the body is lifted off the chest and the respiratory movements remain

unhampered. This is often just enough to get rid of the wakefulness. I discovered the trick when climbing in the Garhwal Himalayas and have proved its value since then. The fact that discomfort with the breathing becomes less noticeable as one acclimatizes suggests that a mechanism has been brought into play whereby the breathing can be maintained at the new level without conscious effort.

A characteristic which has been described as peculiar to the native peoples who dwell permanently at high altitudes is the shape of the chest. This is deeper and of greater capacity than that of persons living at sea-level. A greater capacity of the chest, so long as the lungs are healthy and the ribs mobile, would mean that a greater area of the lung was exposed to aeration. In order to see if our own lungs increased their capacity as we went higher we measured the *vital capacity*. To do this the subject is instructed to take in as

Vital Capacity of the Lungs.

	Lachen 8,800 ft.	*Base Camp* 16,600 ft.	*Camp I* 17,700 ft.	*Camp III* 21,200 ft.	*Base Camp* 16,600 ft.	*Tengkye Dz.* 13,800 ft.
Individual	23.3.36	29.4.36	5.5.36	26.5.36	16.6.36	27.6.36
C.W.	4.3	4.3	4.0	4.1	4.1	4.3
E.K.	4.0	3.8	4.0	3.9	4.0	4.2
E.W.	4.3	4.6	4.8	5.0	5.0	5.2
E.S.	4.6	4.8	5.0	5.0	5.5	5.6
F.S.	–	3.7	3.7	3.8	4.1	–
P.O.	4.0	4.4	4.1	–	4.4	4.5
C.J.M.	–	4.0	4.2	–	4.8	4.6
H.R.	4.3	5.0	4.9	5.1	5.3	5.4
N.H.	3.5	4.2	4.0	–	–	4.6
P.W.H.	3.5	4.1	4.6	4.6	–	4.3

Fig. 1.

much air as possible in a single breath. When the chest seems full to bursting point he is made to blow out the air into a gas meter until he can expel no more. The volume of gas expelled is measured by the meter. In some members the vital capacity had increased at the end of the expedition by as much as 27 per cent., but in others the increase was less marked. This improvement in the vital capacity appears to be one of the ways in which acclimatization can be assisted. But it must be remembered that training alone will produce some change, since in athletes the vital capacity is found to be greater than normal. The test is employed by physicians for assessing the soundness of the lungs. It was one of the many tests to which we were subjected by the Royal Air Force Central Medical Board before going out with the expedition. For various reasons no measurements of the chests of the natives living in Tibet were made. The vital capacity test is unsuitable for this purpose since its performance depends for accuracy upon the intelligent co-operation of the subject, and it is difficult to explain how it should be done in a foreign

language. We did however from time to time have occasion to examine medically most of our porters, many of whom were Tibetans and hillmen. When making these examinations I noticed that the heart sounds were often difficult to hear, and not only that but the normal area of cardiac dullness was reduced in extent, which would suggest that there was in these people some change in the lungs.

A condition known as clubbing of the fingers is frequently associated with states in which oxygenation of the blood is defective. Barcroft observed clubbing of the fingers in the dwellers at high altitudes in the Peruvian Andes. We noticed no such thing in the Tibetans or in our porters.

From all Everest expeditions there have been reports of altitude sore throats, and both in 1935 and 1936 almost every member of the party suffered. From the point of view of keeping the climbers fit for their task the problem of their prevention is important. Several theories of the cause of the condition have been put forward. Hingston thought that they were due to the rapid breathing of cold dry air. Greene suggested that they were due to an infection picked up from the dust of age-old camps during the journey through Tibet. I think that the following explanation is possible. Normally the throat and nose contain bacteria which are harmless, the normal buccal flora. But by breathing the unusually dry air of the north side of the mountain through the mouth instead of the nose—for when you are panting for breath mouth-breathing is the rule—the breath is not moistened by passage through the nose. The result is that the cells lining the upper respiratory passages over which it passes become dried up. In this state they are liable to invasion by the normal buccal flora. In several cases we noticed that the throats were actually ulcerated, and in 1933 Greene observed the same thing. With Shipton the infection spread to his larynx so that he lost his voice and could only issue orders to the porters at Camp III in a hoarse whisper. There was a noticeable improvement in the altitude throats as soon as the moisture-laden monsoon clouds began to pour over the passes from the south on to the East Rongbuk Glacier. When climbing in Garhwal on the southern slopes of the Himalaya these sore throats were not nearly such a common feature of life at high altitudes. The application of liquid paraffin with a spray so as to form a protective film over the throat was tried and found to be inadequate treatment. I can only suggest that an improved mask of the Matthews' respirator type should be used when taking exercise high up. With this mask the moisture in the expired air is condensed on a pad of copper gauze, and then with inspiration the air taken in is moistened and warmed by passage through the gauze. If properly designed the respirator could be worn without there being any obstruction to the breathing.

The heart and circulation

In 1936, as no one was exposed to the strain of going really high, dilated hearts were not to be expected. Only once was the whole party examined for heart-strain and that was after coming down from Camp III for the first time. On that occasion there were no dilated hearts. Apparently they were a feature of previous expeditions, and Hingston said that in 1924 all the climbers who had been to high camps showed evidence of them. Their absence in

1936 is due to the fact that no one had a chance of going higher than 23,000 feet.

Irregularities in the cardiac rhythm have been reported, but were not an outstanding feature in 1936. Once when going up to Camp III at a time when I had a sore throat I noticed that my heart was making extra beats at irregular intervals, but this was the only time at which an irregularity in the heart beat was noticed.

The pulse rate was examined particularly with a view to noting alterations in the basal rate. The rates both sitting and standing were also recorded at various altitudes. A large number of determinations were made but the following table (Fig. 2) records only a few of these for illustration. The features in the case recorded are: that there is no increase in the basal rate until 20,000 feet is reached; there is some increase in the sitting rate and a very definite increase in the standing rate as height is gained. These observations are in agreement with the findings of Hingston in 1924.

The basal rate is the number of beats per minute of the pulse when taken the

Pulse-rate of one individual.

Altitude	*Basal*	*Sitting*	*Standing*
8,800 ft.	*63*	*66*	*81*
15,000 "	*63*	*71*	*85*
16,600 "	*63*	*71*	*89*
20,000 "	*67*	*92*	*102*
21,200 "	*73*	*92*	*114*
21,000 " (three weeks later)	*70*	*90*	*102*

Fig. 2

first thing in the morning with the subject lying quietly in bed. Under normal circumstances the frequency remains very constant for each individual. Any effort such as turning over in bed will send the rate up. Fig. 3 shows the basal pulse rates of eight members of the party at different times during the expedition. In every case except one the rate remained unaltered below 20,000 feet. But in the case of Kempson his rate was constant only below 17,700 feet. In two members of the party the basal pulse frequency remained constant even at 21,200 feet. In six out of eight members of the expedition then the heart was working at an increased rate even under conditions of complete rest whenever they went above Camp I at 17,700 feet. And this happened not only on their first visits to Camps II and III but also during subsequent visits when it was known that they were better acclimatized. Perhaps it is significant that 20,000 feet corresponds roughly to the altitude at which we noticed other signs of deterioration, such as loss of weight and lack of appetite.

It is well known that on going to a high altitude there is an increase in the number of red corpuscles per unit volume of blood and a corresponding rise

in haemoglobin content. Now since the oxygen required by the body for purposes of life and respiration is carried to the tissues by the haemoglobin

Basal-pulse Rates of Different Individuals

Place	Altitude	C.W.	P.W.H.	E.W.	P.O.	E.K.	J.L.G.	E.S.	H.R.
Gangtok	6,000′	62	–	–	–	–	–	–	–
Lachen	8,800′	63	63	–	–	58	48	71	61
Tangu	12,800′	62	–	63	–	–	52	70	–
Kampa Dzong	15,000′	63	–	–	–	65	–	70	–
Tengkye Dzong	13,600′	62	–	–	–	62	–	–	–
Base Camp	16,600′	63	–	–	58	64	–	–	–
Camp I	17,700′	63	–	58	–	82	48	–	56
Camp II	20,000′	67	66	83	64	88	–	–	–
Camp III	21,200′	73	66	83	64	102	64	64	56
Camp I	17,700′	61	64	–	–	67	51	–	55
Camp II	20,000′	69	–	–	–	89	68	–	–
Camp III	21,200′	70	–	–	–	90	–	–	–
Camp I	17,700′	62	–	–	–	–	–	–	–
Camp II	20,000′	65	–	–	–	84	–	–	–
Camp III	21,200′	72	–	–	–	–	–	–	–
Tengkye Dzong	13,600′	64	–	–	–	–	–	–	–
Lachung	8,800′	55	–	–	–	–	–	–	–
Tong	4,800′	54	–	–	–	–	–	–	–

Fig. 3

which is present in the corpuscles, an increase in this pigment will enable more oxygen to be transported. The changes in the blood have always been

Date	Altitude (feet)	Corpuscles per cu.mm.
April 10	700	4,480,000
May 12	4,390	5,240,000
May 21	8,000	6,040,000
May 28	10,000	6,624,000
May 30	11,960	6,760,000
June 1	12,400	6,800,000
June 21	13,300	7,525,000
June 23	15,600	7,840,000
June 26	16,900	7,640,000
July 27	18,200	8,320,000

Fig. 4

regarded as one of the most important factors determining acclimatization. Blood counts have frequently been made at altitudes up to 15,000 feet, and

Hingston quotes a few figures from altitudes higher than this on the Pamir plateau (see Fig. 4). So far as I know counts were not made during Everest expeditions until 1936. It should be mentioned however that Kellas was able to make a count on his own blood at a camp at 20,000 feet before and immediately after ascending Pauhunri (23,180 feet). Fig. 5 shows the number of red corpuscles per cubic millimetre of blood and the percentage of haemoglobin in one member of the 1936 Everest Expedition. The normal figures at sea-level should be: 5,000,000 red cells per cubic millimetre, and 100 per cent. of haemoglobin. It will be seen that there is a progressive

Blood-count and Haemoglobin of one individual.

Date	Place	Altitude	R.B.C.	Hb%
14.3.36	Gangtok	6,000′	4,710,000	93
25.3.36	Lachen	8,800′	4,950,000	96
29.3.36	Tangu	12,800′	4,885,000	96
6.4.36	Kampa Dzong	15,000′	5,110,000	99
11.4.36	Tengkye Dzong	13,800′	5,420,000	105
21.4.36	Shekkar Dzong	14,000′	5,850,000	116
5.5.36	Camp I	17,700′	6,090,000	120
15.5.36	Camp III	21,200′	6,550,000	129
16.6.36	Base Camp	16,600′	6,800,000	134
27.6.36	Tengkye Dzong	13,800′	6,710,000	129
22.7.36	Bombay	S.L.	6,770,000	134
17.8.36	London	S.L.	6,550,000	129

Fig. 5

increase both in the number of corpuscles and in the percentage of haemoglobin present as height is gained. It will also be noticed that the figures have not returned to normal even three weeks after reaching sea-level again. Seven weeks later they were normal.

Fig. 6 shows the percentage increase in the haemoglobin of different members of the party as they went above 6000 feet. From these figures the individual variations in response to altitude can be seen, and they can be briefly summarized as follows:

1. The maximum increase in the Hb. content of the blood of any individual was 48 per cent.; three out of the eight members attained this figure: they were E. W., F. S., and J. M. (In the case of J. M. his polycythaemia was twice interrupted by attacks of malarial fever.)
2. The average maximum increase was 36 per cent.

3. In the cases of E. W., E. E. S., and to a less extent E. K., the percentage increase had become marked at the time of reaching Kampa Dzong (15,000 feet). In the remaining five it was delayed until Tengkye Dzong.
4. In the case of E. E. S. his Hb. level appeared to respond more rapidly than the others to changes in altitude.

The changes in the blood appear to follow closely the stages in our ascent, as can be seen from the chart (Fig. 7), where there are two steep rises in the red cell and haemoglobin curves at a time when there have been two periods of steep ascent. On the same chart another series of figures have been plotted, representing changes in the reaction of the urine.

The deep breathing which becomes necessary on going high in order to keep up the oxygen tension in the lungs results in carbon dioxide being washed

Percentage increase in Haemoglobin

Place	Altitude	C.W.	E.W.	E.E.S.	E.K.	J.L.G.	N.H.	F.S.	J.M.
Gangtok	6,000′	0	0	0	0	0	0	0	0
Lachen	8,800′	3	-	9	-	-	0	-	-
Tangu	12,800′	3	3	9	-	-	-	-	2
Kampa Dzong	15,000′	3	25	25	17	-	-	-	-
Tengkye Dzong	13,800′	13	-	-	17	-	9	-	5
Shekkar Dzong	14,000′	25	-	-	-	-	17	-	-
Base Camp	16,600′	-	-	-	21	21	-	33	43
Camp I	17,700′	29	29	39	-	-	-	-	38
Camp III	21,200′	39	44	39	34	40	-	48	-
Base Camp	16,600′	44	-	-	-	-	-	48	-
Tengkye Dzong	13,800′	39	-	28	-	-	21	-	48
S.S. Mooltan	S.L.	44	48	35	-	40	-	-	38

Fig. 6

out of the lungs. But carbon dioxide is an acid gas and its loss from the body tends to leave the blood more alkaline. In order to compensate for this tendency towards alkalosis the kidney excretes more alkali and the reaction of the blood is restored to normal. Since it is difficult to estimate directly these changes in the reaction of the blood an indirect method of doing so was sought. This was by estimating the reaction of the excretion from the kidneys. In Fig. 7 an upward deflection in the curve indicates an increase in the *p*H or alkalinity of the urine. Two peaks of alkalinity are present. Each one appears at a period of rapid ascent and precedes a rise in the blood and haemoglobin curves. The exact interpretation of these findings is at present difficult and debatable. But it can be said that there appears to be a tendency towards alkalosis at a time when the ascent is rapid and before the blood count has adapted itself to the new level.

Blueness of the face and lips and lividity of the fingers were noticed at the

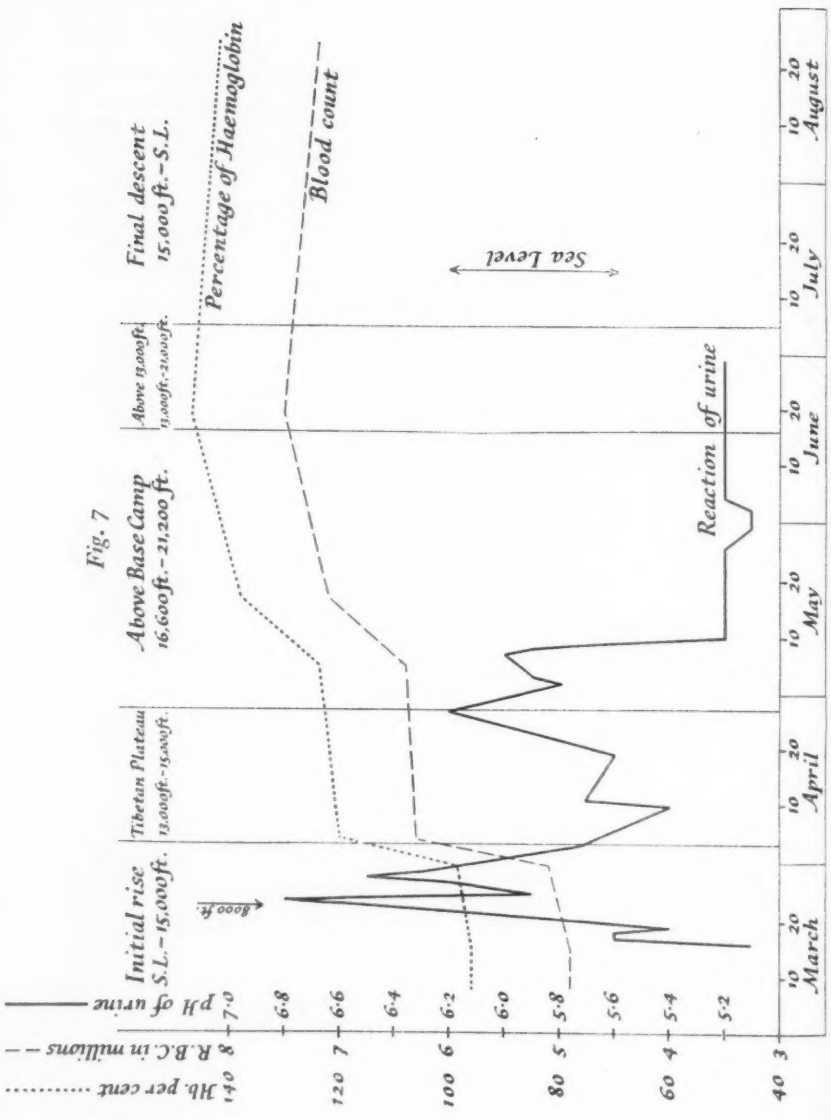

Initial rise
S.L.–15,000ft.
Tibetan Plateau
13,000ft.–15,000ft.
Above Base Camp
16,600ft.–21,200ft.
Above 19,000ft.
19,000ft.–21,000ft.
Final descent
15,000ft.–S.L.
8000ft.
Percentage of Haemoglobin
Blood count
Sea Level
Reaction of urine
Hb. per cent
R.B.C. in millions
pH of urine
140
120
100
80
60
40
8
7
6
5
4
3
7·0
6·8
6·6
6·4
6·2
6·0
5·8
5·6
5·4
5·2
10
20
March
April
May
June
July
August

Fig. 7

beginning of the expedition, but curiously enough did not seem to be so pronounced later on. This is remarkable because people with blood counts which are higher than normal usually become cyanosed or livid more readily. Perhaps we became accustomed to our companions' complexions as one becomes accustomed to new faces.

Muscular power

Lassitude and a sense of muscular weakness are prominent features of life at great altitudes. They were first noticed at about 12,000 feet on the outward journey but, like the difficulty with the breathing, soon passed off as we became acclimatized, only to reappear again when we got to Camp I. Above 20,000 feet there always appeared to be some lassitude. For the first few days at Camp III I found that I was always longing to sit down and do nothing. I can only compare the feeling to that sense of weakness which is experienced on first getting up after a long illness. The lassitude together with a feeling of giddiness was often particularly noticeable on getting up in the mornings. Although the condition improved after a short time spent at this camp, in my own case I found that it never disappeared completely. When climbing on the North Col we noticed that the muscles tired more rapidly than at lower altitudes. Towards the end of our stay on the mountain however this lassitude and rapid fatigue on exertion were the only signs of mountain-sickness.

The mind and special senses

At altitudes such as were attained by the 1936 expedition there appeared to be no diminution in acuity of hearing and vision, though this has been reported on previous expeditions.

There was a very distinct disinclination for serious mental work above about 20,000 feet, which must to some extent be my excuse for not bringing back more information than I have done for this paper. But apart from this no serious mental changes were noticed. Tempers are said to be irritable at high altitude, but although conditions on the North Col last year were provoking to say the least of it, we never really quarrelled seriously.

The digestion

Loss of appetite is a troublesome consequence of life above 20,000 feet. In 1936 appetites were better than usual at Camp III, but even then they were much below normal. During the reconnaissance in 1935 we made a point of writing down the estimated quantities of the various things that were eaten at each meal. On looking at these notes afterwards it was clear that everyone was eating far too little up at the higher camps, although at the time they would stoutly have maintained that they were eating enormously. This failure to take enough nourishment on the part of the climbers was reflected in their weight records. Everyone lost several pounds in weight whenever they went above 20,000 feet for any length of time, and much of this weight was regained on going down to the Base Camp for a few days. It is interesting that the porters did not lose weight like the climbers; but this is probably accounted for by the fact that when they are with an expedition they

are fed better than normally. This loss of appetite interested me, and I wondered whether it might not be connected with the process of acclimatization. Is it not possible that the hydrochloric acid which normally should appear in the stomach following a meal is conserved for purposes of neutralization in the body at high altitudes? For as we have already mentioned, there is a tendency for the blood to become more alkaline high up and any loss of acid from the body, as in the gastric secretion, would still further accentuate this alkalosis—a state of affairs which is the opposite of that required for acclimatization. If it is true that the hydrochloric acid is retained by the body and not put out during digestion, then the administration of small doses of diluted hydrochloric acid (or even of acid salts such as ammonium chloride) might help to stimulate the appetite.

An attempt was made to detect changes in the acidity of the gastric secretion at two different altitudes by means of a test-meal. The most unpleasant part

Gastric Acidity

	C.B.M.W.		E.W.	
	17,700 ft.	21,200 ft.	17,700 ft.	21,200 ft.
Fasting	○	○	○	○
→ 15 min.	+ +	○	○	○
30 "	+	○	+	○
45 "	+	○	○	○
60 "	+	○		
Histamine	+ +	+ +	+ +	+ +

+ .. *Free Hydrochloric acid present*
○ .. *No free acid present*

Fig. 8

of the performance of this test is persuading your victim to swallow the stomach tube. It was only fair therefore that I should set the example by doing the first test-meal on myself. Wigram, being a student of medicine, volunteered to be the second victim of the experiment. But as he remarked afterwards, the fact that he was given a little icy cold alcohol down a tube was hardly sufficient compensation for such good nature on his part. In performing a test-meal the subject is made to swallow the stomach tube first thing in the morning before any food has been taken. The fasting contents of the stomach are then withdrawn and tested for free hydrochloric acid. Immediately afterwards a definite quantity of alcohol (the meal) is run down the tube into the stomach. Then at fifteen-minute intervals samples of the gastric contents are withdrawn and tested for the acid. If no acid appears in the later samples then an injection of histamine is given into the arm, and a few minutes later another sample is withdrawn and tested. This last sample should contain free hydrochloric acid; if it does not, the subject is one of those people who cannot secrete the acid at any time. The results

of this test performed upon two of the climbers, first of all at Camp I and then at Camp III, are shown in Fig. 8. It will be noticed that in both cases there was free hydrochloric acid in at least one of the samples following the meal at Camp I, whereas at Camp III there was no acid at any time until histamine had been given.

Acclimatization

We now come to consider what is the sequence of events in the process of acclimatization. Breathing becomes deeper and more rapid in order to increase the amount of oxygen reaching the alveoli or farthest spaces of the lungs. At first this increased ventilation of the lungs is partly voluntary and for this reason is felt as a difficulty with the breathing. But as we have already mentioned, the deep breathing causes the acid gas carbon dioxide to be washed out of the lungs and so tends to make the blood more alkaline. With the loss of carbon dioxide from the circulation however the normal stimulus to the breathing mechanism has gone, and the depth of the breathing dies down again. In order that the deep breathing, which is such an advantage to the body at high altitudes, may continue the kidneys after a time learn how to get rid of the excess of alkali from the blood, and thus its reaction is restored to normal. In this way the loss of carbon dioxide is compensated for and the breathing allowed to go on at the new level. In addition to this mechanism there is the one whereby the number of red corpuscles is increased in the blood. At first this increase is probably brought about by contraction of the spleen. When this organ contracts red cells are squeezed out from its meshes into the general circulation as water is squeezed from a sponge. Obviously the number of red cells in the circulation can quickly be increased by such means. At a later stage it seems likely that there is actually increased formation of red cells by the red bone marrow, which appears to be stimulated into activity by lack of oxygen. These are the principal means by which the body can adapt itself to the changed state of the atmosphere met with at high altitudes. The extent to which these changes are taking place during the climbing of Mount Everest may be judged from this paper.

Deterioration

Before leaving the subject of acclimatization in connection with the climbing of Mount Everest something must be said about the deterioration in the physical condition of the climbers which is alleged to set in above a certain altitude. As a result of experiments with animals which were kept at low atmospheric pressures for a long time, Argyll-Campbell and Sir Leonard Hill came to the conclusion that it was useless to attempt to acclimatize to altitudes greater than 21,000 feet by staying for prolonged periods at the higher camps on the mountain. Above this altitude their animals eventually died, and when examined were found to have dilated hearts and fatty degeneration of all their organs. It is possible to argue of course that their results with animals need not necessarily have any bearing upon what happens in the human organism under similar circumstances. But it is interesting to note that after the 1933 expedition it was decided that in future the climbers ought not to stay in the camps above Camp III (21,200 feet) for longer than

is absolutely necessary. In 1936, after the first attempt to get above the North Col the whole party retreated to Camp I, having lived at Camp III for a period of eleven days on that occasion. Morris and Smijth-Windham were both at Camp I when we came down, and they told me afterwards that we all looked thin and ill when we came into camp. It was also remarkable how we at once began to eat with our accustomed appetites at this camp (17,700 feet). At Camp III most of us had been worried by sore throats, but on going down to lower levels they improved remarkably. The increase in the basal pulse rate which was observed in most of the climbers whenever they went above 17,700 feet has already been mentioned.

To summarize, the evidence which points to deterioration taking place at about 21,000 feet is: loss of appetite, with attendant wasting and loss of weight which is rapidly regained on going to lower levels; an increase in the basal pulse frequency which is only present above 17,700 feet; and in experiments with animals, the inability to prevent them from ultimately dying with fatty degeneration of their organs.

Have we any evidence that acclimatization is still going on at 21,000 feet in spite of the fact that deterioration in the physical condition may have started? To begin with it should be mentioned that we all felt much less distress on our second and third visits to Camp III. The only other evidence is to be derived from the blood counts. Between the time of our first visit to Camp III and our final return to the Base Camp at the end of the expedition there was in most cases a further increase in the red cells and the haemoglobin-content of the blood. Therefore it can at least be said, that our later stays at 21,200 feet did not prevent the blood count from continuing to rise. This finding appears to be in agreement with some observations which were made recently by Matthews in the Andes.

The oxygen problem

When a man goes to a high altitude he has to breathe an atmosphere which contains less oxygen than there is at sea-level, though the proportion of oxygen to nitrogen remains the same: that is, oxygen still forms 20 per cent. of the atmosphere. What has altered is the barometric pressure, so that the pressure exerted by each of the gases composing the atmosphere has altered also. Oxygen passes from the air in the lungs into the blood, which is circulating through those organs, as a result of the pressure exerted by the gas, and the amount which is taken up by the blood depends upon this pressure. If the partial pressure of oxygen in the breathed air is reduced, as it is at high altitudes (and in low pressure chambers at sea-level), then less of it is taken up, the blood leaves the lungs less fully saturated with the gas, and so has less to deliver to the tissues. Enough oxygen must be supplied to the tissues if their life and function are to be maintained. It is lack of oxygen for the tissues which gives rise to the symptoms of mountain-sickness and which calls forth the adjustments known as acclimatization.

If a sample of blood is exposed to air containing oxygen at a known partial pressure it becomes partly saturated with the oxygen, *i.e.* a definite percentage of the haemoglobin present in this blood becomes converted into oxyhaemoglobin. If the partial pressure is increased the blood will become more fully

saturated; but if it is reduced the saturation will become less complete. A curve can be constructed which will show the relationship between partial pressures of oxygen and the percentage saturation of the blood. This is known as the Dissociation Curve of Oxyhaemoglobin in Blood. Dr. Kellas has plotted the calculated alveolar oxygen tensions for altitudes corresponding to a number of well-known mountains (Fig. 9). The curve shows that up to about 10,000 feet the blood is almost fully saturated with oxygen, but at about 15,000 feet the percentage saturation is beginning to fall. By the time 20,000 feet is reached the curve is steepening rapidly and with every 1000 feet rise above this altitude there is a correspondingly rapid fall in the percentage saturation. At a height corresponding to the summit of Mount Everest the degree of saturation is only about 40 per cent. From a consideration of the curve it seems clear that the difficulties in ascending above 20,000

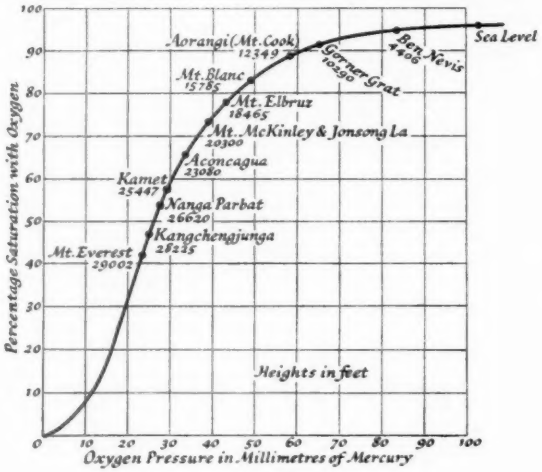


Fig. 9

feet will increase considerably; an observation which is borne out by the accounts of all those who have come back from the higher camps on Mount Everest. Thus, although the climbers have already struggled to 28,000 feet on the mountain, there is no reason to suppose that because they have done so they are bound to be able to climb the last 1000 feet without using oxygen.

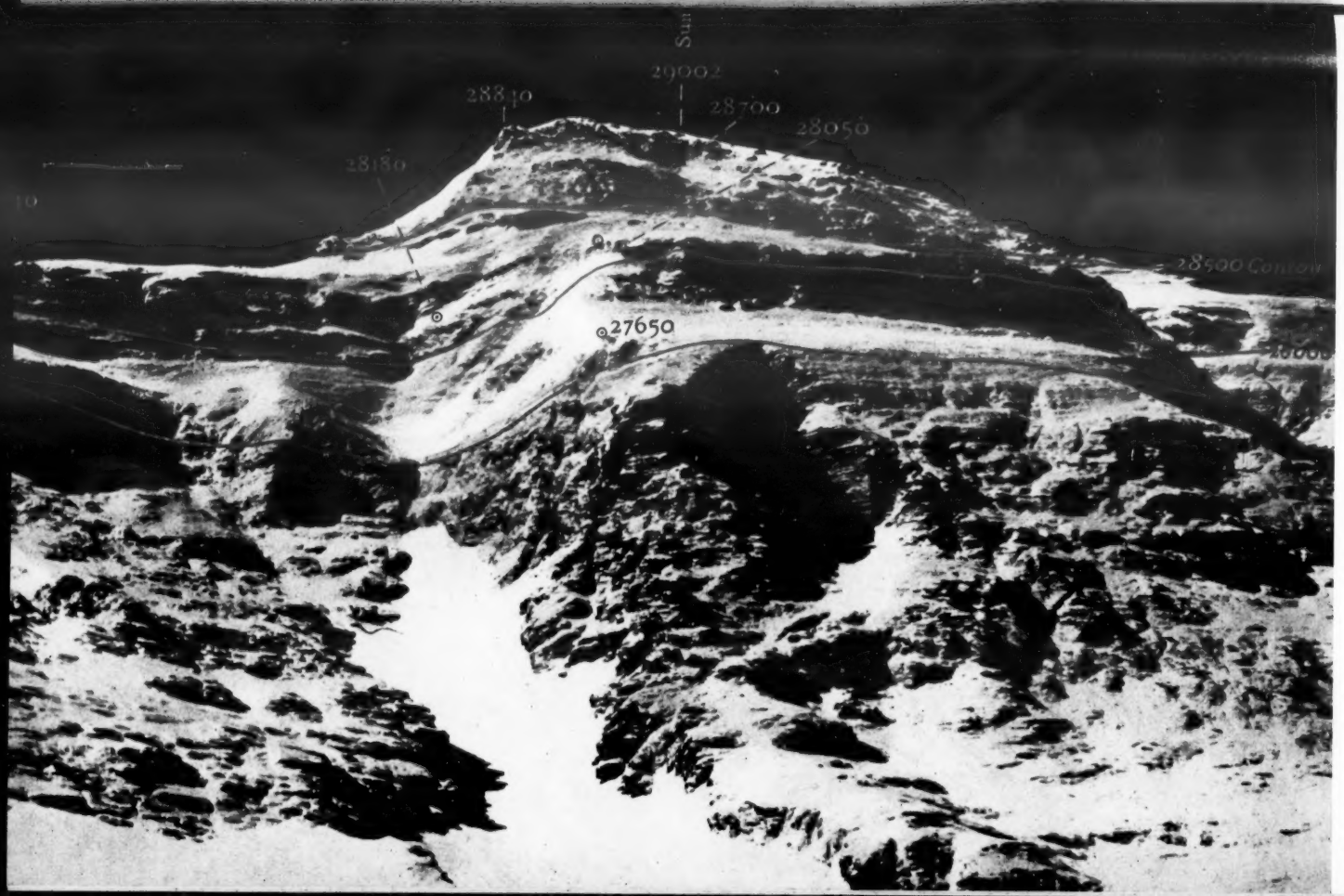
This brings us to a consideration of what happens when the partial pressure of oxygen in the breathed air falls beyond certain limits. Symptoms which are directly attributable to the diminished pressure are met with. For instance, if an airman goes rapidly to a great altitude he loses consciousness without warning. The same thing happens if he is put into a closed chamber at sea-level from which the air is rapidly exhausted. In 1875 Tissandier and his companions made their famous ascent in a balloon from Paris. At 26,500 feet Tissandier lost consciousness. He recovered to find the balloon descending, but his two companions were dead. It has been suggested that such an accident

might happen on Everest, but I do not think it is likely when we consider what happens if the oxygen pressure is reduced more slowly. With a more gradual onset of oxygen-lack the train of symptoms is as follows. The intellect and the senses become dulled without the subject being aware of what is happening. Visual acuity is diminished and sensation impaired. The subject may be in danger and not realize it; or he may realize his danger and yet be incapable of deciding upon a line of action that would put him in safety. Eventually there is paralysis of the legs and arms, and ultimately loss of consciousness. On the extreme heights of Everest the climber is likely to be brought to a standstill by the fatigue in his muscles (or by actual paralysis) before losing consciousness. He would however be exposed to the risks due to mental impairment, such as the failure to realize the danger of his position and carelessness in his movements on difficult ground. Apart from the fact that it may not be possible to reach such an altitude as 29,002 feet without using oxygen, I think that the dangers consequent upon mental impairment form the strongest argument in favour of its use on the last lap to the summit.

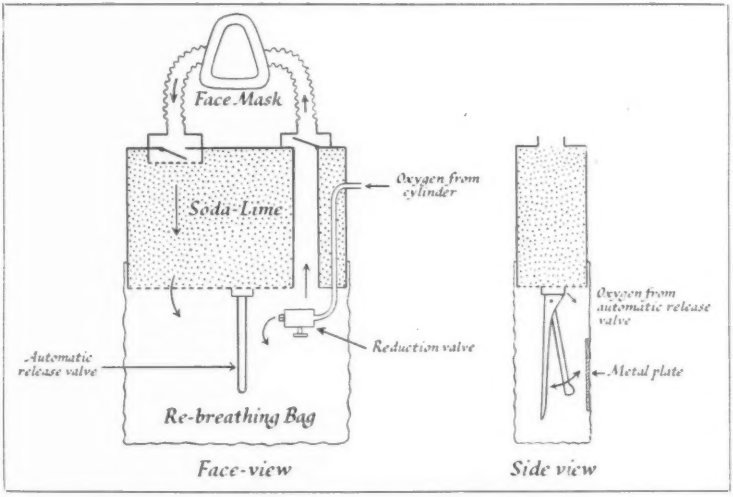
Oxygen apparatus and its use

Whatever type of apparatus is used, its object is to increase the pressure of oxygen in the alveolar spaces of the lungs. This object can be achieved in one of two ways. In the original types of apparatus the outside air was breathed from a bag to which oxygen was added from a cylinder at a fixed rate. The disadvantages of this method are that much of the oxygen is wasted by being expired from the dead spaces of the lungs into the outside air; that there is an uncomfortable drying of the throat; and that moisture and heat are lost from the body in the breath. Furthermore, when the ventilation of the lungs increases as it does during exercise the partial pressure of oxygen in the bag will fall. That this apparatus is wasteful of oxygen can be seen from the fact that in order to raise the partial pressure of oxygen in the air at 30,000 feet from 53 mm. of mercury to 110 mm. it is calculated that oxygen must be supplied at the rate of about 9 litres a minute. A partial pressure of 110 mm. of mercury corresponds to an altitude of about 12,000 feet, so that to bring a climber down to this level it would be necessary to supply him with oxygen at that rate. But the body only uses oxygen at the rate of approximately half a litre per minute when at rest and up to 2 litres per minute during exercise, as can be seen from the table which was worked out by Zuntz on Monte Rosa (see Fig. 10). An apparatus of this type was taken by the expedition in 1936. It contained two cylinders of "Vibrax" steel each holding 750 litres of oxygen and the reduction valve was set to deliver 6 litres a minute, though it was capable of adjustment to deliver any other quantity. With such an apparatus the supply was 1500 litres, and this flowing at the rate of 6 litres a minute would last just over four hours. Its weight was approximately 30 lb.

In another type of apparatus, instead of air being breathed to which oxygen is added, oxygen only is breathed and the carbon dioxide in the expired breath is absorbed by passing it through a canister containing soda-lime. The breathing circuit is completely enclosed, so that nothing is exhaled into the outside atmosphere. Such an apparatus is similar to that used in rescue work down coal mines and in submarine-escaping apparatus. Its advantages would



The summit of Mount Everest from the North Col



Re-breathing type of oxygen apparatus

The apparatus in use

seem to be that no oxygen is wasted, that heat and moisture are not lost by breathing out into the external atmosphere, and that the pressure of oxygen breathed is the same as that of the external atmosphere (*i.e.* approximately 250 mm. of mercury at 30,000 feet), a pressure which is well above the partial pressure of oxygen in the atmosphere at sea-level. The apparatus therefore should theoretically bring the climber at 30,000 feet down to sea-level conditions. The oxygen-breathing gear was designed and made for us to use on the mountain by Siebe Gorman, the well-known firm of submarine engineers. Two sizes were taken. The smaller of the two weighed 25 lb. and carried a cylinder, made of "Vibrax" steel, of 500 litres capacity. Supposing the rate of consumption of oxygen when climbing on Everest was 2 litres a minute, then the supply would last just over four hours. The larger apparatus weighed 35 lb. and carried a cylinder of 750 litres capacity, and on the same basis would provide oxygen for a period of six hours. The reduction valve in the respirator was actually set to deliver half a litre a minute, or the amount of oxygen required by the body when at rest; but by means of an automatic release valve a greater supply could be obtained from the cylinder as required during exercise.

The re-breathing type of apparatus has been criticized on the following

	Oxygen required per minute
Sea level at rest, fasting	*233 cub. c.*
Monte Rosa do.	*260 "*
Ascending glacier on Monte Rosa ...	*1329 "*

Fig. 10

grounds: that there is no advantage in bringing the climber down to sea-level conditions, and that such a change may even do harm; that soda-lime absorbs moisture, so that there is a loss of fluids from the body through the breath; and that nobody could tolerate having a mask over their face at 28,000 feet. In answer to these criticisms I would first of all point out that if the increase in the blood count is really one of the more important indications of acclimatization then it seems unlikely that by breathing oxygen for a few hours on end acclimatization would be seriously affected, for as we know it is a matter of weeks and not days before the blood count begins to fall after reaching sea-level. Then with regard to the moisture which might be absorbed by the soda-lime, I understand that many of the patent absorbing materials such as "Protosorb," which was used in the apparatus under consideration, are practically non-hygroscopic. And lastly, as far as the intolerance of a mask over the face is concerned, the reply is that with the proper oxygen supply given by this apparatus the climber would not be at 28,000 feet but at sea-level. A mask indeed would even be an advantage since it would protect the face from the wind and allow it to be muffled up to the eyes with clothing.

The re-breathing respirator was tested both at home in the low-pressure chamber and in Tibet on the mountain. The trials at home were not as thorough as was desirable on account of the limited time at our disposal,

and those on the mountain were not made at a sufficiently great altitude to give us any information of great value. But in order to find out what could be done in the apparatus, Shipton took it down to Box Hill and made several ascents of a steep slope in it. At the Box Hill trial he had the apparatus on for an hour and forty minutes in all. During that time he ascended 1750 feet in the course of 67½ minutes' climbing, so that he was climbing at the very fast rate of 1550 feet an hour. The average angle of the slope on which the trial was made was measured, and worked out at 32 degrees. The surface was wet chalk. The amount of oxygen used during the hour and forty minutes of the trial was just under 250 litres, or half the supply available. A few days later I went to the same slope to test another apparatus and so had an opportunity of seeing it. I came to the conclusion that a surface of wet chalk set at a steep angle is about the most diabolical place imaginable. I have never wasted so much energy in stepping up only to slide down again as I did in the course of an hour's climbing that afternoon. On the top of it all the apparatus was a trial one and was not working as smoothly as it might have done; in consequence the unfortunate subject of the experiment became half asphyxiated and developed a splitting headache.

The oxygen apparatus was used once or twice in the course of the expedition in order to try it out and to train people how to use it. This training is most important, and until the climbers can be persuaded to devote a certain amount of time to getting used to the gear and moving about in it, we shall get no farther with the oxygen problem. On the slopes of the North Col I climbed in it for a short time and found that I could advance much faster and without the fatigue which normally is experienced at that altitude. It was worn by several members of the party to make ascents of over an hour's duration above the Base Camp at 16,600 feet, and no one suffered any ill effects when it was taken off. But the most convincing trial was done at Tangu. Here, before any of us were properly acclimatized, I used the apparatus to climb for at least 1000 feet up the hillside behind the bungalow. And yet with 35 lb. on my back I was able to climb just about twice as fast as two of my companions who were going without it.

The question which arises is: How should the apparatus be used on the mountain? Personally I think that to try to make the ascent using oxygen from below Camp V would be impractical and dangerous. I think that it should be used on the last lap only, and then only by a specially trained oxygen party. It would be quite useless and dangerous to let those who feel "anti-oxygen" have a closed type of apparatus up at Camp VI to use in the event of their failure to climb the mountain without it. It has been suggested that oxygen might be used in camp and at night time only, in order to do away with deterioration. But if one really believes, as do some of us who consider the matter from the physiological as well as the mountaineering point of view, that it may be impossible for a man to reach 29,002 feet without using oxygen, then such a method of administration contributes nothing towards the attainment of the summit.

A last point which requires consideration is whether a six-hour supply will be sufficient to carry the climber from the last camp to the summit and down again. Shipton has estimated that without oxygen the last 1000 feet

will take about sixteen hours up and down. Even with 30 lb. on one's back it should be possible to climb at the rate of 500 feet an hour over quite difficult ground when at moderate altitudes and without oxygen. We know that this can be done in the Alps, and in the Himalayas people have climbed up difficult rocks with loads of 20 lb. on their backs. If, then, we can produce an oxygen apparatus which will bring the climber down to sea-level when on Everest, even though it does weigh 35 lb. and has only a six-hour supply, he should be able to get to the top and down again within this time.

DISCUSSION

Before the paper the PRESIDENT (Professor HENRY BALFOUR) said: Dr. Warren, our lecturer this afternoon, has already spoken in this Hall when, after Mr. Ruttledge's paper on the last expedition to Mount Everest, he offered a few remarks on the medical aspects of the expedition. This afternoon he is going into the matter more deeply.

As you know, the Mount Everest Expedition was not successful in its objective, and that non-success was due almost entirely to the very abnormal weather conditions that obtained in 1936. Weather conditions are not in any way under the control of the medical members of the expedition, but there are other matters of almost equally great importance that are subject to control by medical officers: questions of health, and not only questions of the health of the expedition itself, but the problem of trying out fresh apparatus. The medical officers, Dr. Noel Humphreys and Dr. Warren, did yeoman service in not only keeping the expedition healthy, but also in conducting experiments which should be of use to future expeditions. I have great pleasure in calling upon Dr. Warren to read his paper.

Dr. Warren then read the paper printed above, and a discussion followed.

The PRESIDENT: I would ask Mr. Matthews who has just demonstrated the oxygen apparatus to us to tell us something of his sensations in that connection.

Mr. B. H. C. MATTHEWS: There seems to be very little obstruction to respiration in the apparatus. I have had it in Cambridge during the last two days for the purpose of doing tests with regard to resistance and performance. It seems to me an enormous advance on all previous apparatus I have seen for the purpose. The difference in oxygen economy between an apparatus with a closed circuit and the open-circuit type of apparatus seems to be an overwhelming argument in favour of the use of the former type. The greatest advantage of the apparatus Dr. Warren has shown seems to me to lie in the enormously increased speed of climbing that would be possible at a high altitude, so that the time during which a man is above the danger level (28,000 feet) in extremely low pressure can be reduced, according to Dr. Warren's figures, by about five times. Thus, instead of spending twenty hours in reaching the summit of Mount Everest from the last camp, one might spend only a matter of four hours when using this apparatus.

I should like to express my great admiration for the work Dr. Warren managed to do under what I know were very difficult conditions. I have tried to take observations at 20,000 feet and I know it is by no means easy.

One point interested me very much in Dr. Warren's figures for the blood capacity in that I noticed there was a continuous increase after the climber came down from the greater height to 20,000 feet. Acclimatization went on for a long time at that height. That agrees with some observations made in Chile

about two years ago on what I think were possibly the most acclimatized group of people in the world: some Chilean sulphur miners, who live at 17,000 feet and work every day at 19,000 feet. Most of them have been doing this for ten years and they have been doing hard physical work at 19,000 feet. The effect of their acclimatization is instanced by the fact that they start at 17,000 feet in the morning, rise early and walk up the 2000 feet to the mine, sandwich in a hard day's work, come down in the evening when you would expect them to be exhausted, and proceed to play what they call football on the flat ground outside the mining camp. We persuaded some of these men to let us have samples of their blood and they confirmed the suspicion, shown again in Dr. Warren's figures, that acclimatization goes on for a very long time.

We were in Chile for about four months and living above 16,000 feet or so ourselves. The miners, as I have said, had been there for ten years, and whereas our haemoglobin rose to 125–135 per cent. of its sea-level value, theirs was about 160 per cent., so that acclimatization had gone much farther during a long-term residence.

I was particularly interested in Dr. Warren's observations on the acid base balance because we were observing a different aspect of that in Chile, in the base reserve in the blood, and we found that it fell very markedly at a high altitude. It seemed that there were two phases in acclimatization. There was the acid-base side of it and the adaptation to more rapid breathing which would normally make the blood alkaline; and a second and, as far as I could see, not necessarily related adjustment in the quantity of haemoglobin. It seemed to us that these two factors which are usually considered together really worked independently and that the increase in the haemoglobin appeared to be, to some extent, independent of the change in the reaction of the blood, and to continue long after the acid-base acclimatization was complete.

Lastly, I should like to ask Dr. Warren if he could tell us anything about his views on the question of high altitude deterioration. It is a question I know nothing about myself but I should be interested if he could say anything in regard to it.

The PRESIDENT: Mr. Wager has explored high altitudes in several areas, and we would like to hear something from him.

Mr. L. R. WAGER: I should like to congratulate Dr. Warren very much indeed on the results of his work. It is not an easy matter, as he said, to make oneself carry out experiments at such high altitudes; and it is not an easy matter to persuade the other climbers to undergo the tests; but he succeeded in doing it, and it is a great achievement.

I do not think the oxygen apparatus which Dr. Warren has shown will appeal to very many of the climbers unless they are, as he said they must be, real enthusiasts for the oxygen method. I am quite sure he is right when he says that in order to use the apparatus effectively the men will have to practise a great deal and be really keen on using it. In fact there will have to be two parts to the Everest Expedition: one that believes that it is impossible to get to the summit without an oxygen apparatus, and another part, which I hope will always exist, that believes that it is perfectly possible.

One difficulty about the apparatus that strikes me is the large number of valves. As Dr. Warren has said, one's mental powers are reduced at high altitudes. It would no doubt be possible to carry out routine adjustments to keep the apparatus going, but supposing any slight thing went wrong due to cold or a bump against the rocks, then I am afraid the mental powers of the climbers would probably not be sufficient to put the trouble right. Unless they could do it quickly they might collapse if they were no longer receiving extra oxygen.

I would also like to ask Dr. Warren whether the effect derived from the oxygen carried is not rather less than in the other form of apparatus. In the older apparatus you do breathe some of the air blowing around the mountain as well as that coming out of the cylinder, whereas in this apparatus, so far as I can see, you only breathe the oxygen you are actually carrying.

However, these are all minor points of the oxygen problem. The part of Dr. Warren's work which particularly appeals to me concerns the changes that go on under normal acclimatization and I think that, if many more of the excellent experiments which Dr. Warren has been doing and which were done to some extent on the earlier expeditions could be carried out on the next expedition, we should probably learn something of how the remarkable process of acclimatization is taking place. Personally I think it would be more satisfactory to climb the mountain by means of acclimatization, and these experiments may indicate how acclimatization may be improved or fostered in the climbers.

The PRESIDENT: I do not know whether there are any physiologists or other specialists here who would like to ask Dr. Warren a question or two. If there are, we would be very glad to hear them.

A FELLOW: May I ask Dr. Warren whether, in the present stage of knowledge of the physiological effects of high altitudes, it has been definitely established that deterioration occurs at any altitude, even up to 28,000 feet.

General C. G. BRUCE: I really am absolutely the worst qualified of anybody in the room to offer any comments on the paper to which we have listened, but I thought I might usefully make one or two remarks upon the attitude of the earlier expeditions. If you read the 1921 book on the earlier expedition you will remember what trouble Mallory had to get to the North Col even during summer; how his men were all tired out; and how a number of them collapsed. You must remember that 23,000 feet in those days had a very great reputation, which is now torn to shreds. In fact, only once before in those early days had a climber, Mr. C. F. Meade on Kamet, slept a night at 23,000 feet. The Sherpas and others started off in those early days fearful, not so much of the mountain and of high altitudes, but of the invasion of sanctuaries. Then in 1922, when our climbers showed the way and confidence was established, and for certain other reasons as well, the men went up to the North Col without turning a hair; they carried heavy loads up and developed confidence, so that the results were very fine indeed. Many men stayed on the North Col at 23,000 feet for fourteen whole days and did an immense amount of work into the bargain.

Then came the expedition of 1924. The attitude of that expedition was that anybody who was not a complete cripple could go up to 23,000 feet in perfect comfort, with the result that we have seen. It is very clear that the psychological outlook is of great importance. A mountaineering tradition has now been established. People often say that as most Sherpas live at a high altitude they are little affected by that altitude. But that is not always the case, and it is to be remembered that one of Mallory's men who did very good work came from Sedongchen, which is only 5500 feet above the sea. Lhakpa Chédé was a Darjeeling man, so that he had not been one of those who were regularly living and working in the high mountains, though fairly accustomed to them. He was also one of Norton's particular men. Actually in 1921 he was very ill from malaria, but in 1924 he was able to work hard and climb so well that he was obviously one of the strongest men in the party, carrying loads to 27,000 feet.

For the future of mountaineering in the Himalayas this is all very encouraging, because there are many other and very good people to be found of almost equal value: they are terrified of the mountain at present, but nevertheless if we can only give them confidence, as the Sherpas have got confidence now, we can

find other helpers who will be really useful for further expeditions in most parts of the Himalaya.

The PRESIDENT: I now call upon Dr. Warren to reply to the questions and remarks that have been made.

Dr. WARREN: The main point to which I have to reply is in regard to deterioration. I think that the 1933 expedition and later expeditions have all come to the conclusion that the longer a man is kept above Camp III, at about 21,000 feet, the more does his physical condition deteriorate. It was very noticeable, I think, both during the reconnaissance and last year that people looked ill when they came down from Camp III after being up there for some time; and at Camp III they would not eat, as I mentioned in the paper. You cannot get a person to eat enough food at that camp because the appetite is completely lost. A man will tell you that he is eating enough, but it is only when you get him to write down and have taken an analysis of what he is eating that you find he is not taking sufficient food. Of course there is a certain amount of individual variation. Some eat better than others. Shipton is quite convinced that you should never keep a man a minute longer than you can help above Camp III, but I think he is an extremist in that matter.

Some experiments by Argyll Campbell on mice showed that they would live and flourish at pressures of oxygen which corresponded to about 20,000 feet, but that at lower pressures they gradually died from fatty degeneration of their organs. It is rather interesting that the altitude at which this happened should correspond roughly to the altitude at which the physical condition of the climbers deteriorates. The matter requires a great deal more investigation. It is time that an Everest expedition took out with them a small party of people trained for the particular job of working out this problem and able to do some useful work. I do not think they would impede the expedition very much, because in 1935 we had with us Spender, who ran his own part of the show very well and did not interfere in the least with the climbing part of the expedition. The outcome of an expedition is a gamble in any season because so much depends on weather conditions. But if it could return with information on this subject alone, gathered by trained observers, it would have fulfilled a useful purpose.

As to Mr. Wager's question in regard to breathing oxygen only, actually the whole point of the closed apparatus is that because you are breathing oxygen only it is of infinitely greater value to you than breathing oxygen diluted by the outside atmosphere. The advantage is that it puts up the pressure of your oxygen.

Mr. WAGER: I meant that you do get some oxygen from the cylinder and some from the air with the older apparatus. In the apparatus you have shown us the oxygen all comes from the cylinder.

Dr. WARREN: You think the air itself might be beneficial?

Mr. WAGER: Yes, there is a small amount of oxygen in the air.

Dr. WARREN: Perhaps this will answer the question. I believe people have been able to breathe in an atmosphere of pure oxygen, with CO_2 absorbed, for periods up to twenty-four hours without any harm accruing. In the open apparatus such a lot of the oxygen is wasted in the breath which you expire. You do not use all the oxygen you take in at inspiration; you only use a comparatively small quantity, the rest is simply blown out into the external atmosphere and lost.

The PRESIDENT: We have been dealing with very practical problems this afternoon and one can only sympathize with the wish expressed by Dr. Warren that scientists capable of collecting the necessary statistical matter should

accompany expeditions. It seems to me to be wasting an opportunity not to appoint people who can devote themselves to the scientific aspect of expeditionary work and one does hope very much that, as far as it is possible, scientists will be provided and be accommodated on the next expedition to Mount Everest. But the work that has been done so far by Dr. Warren and others is all very much to the good, inasmuch as each set of observations in regard to the health and capacity of the expedition necessarily serves as a further stepping-stone to success in this great objective, the climbing of the greatest height in the world.

I must not detain you longer because you have already had a full afternoon and a very instructive one. All I would do now is to ask you to express your thanks and appreciation to Dr. Warren for the research work which he has done and for the practical paper which he has read.

THE 600-FOOT PLATEAU IN PEMBROKESHIRE AND CARMARTHENSHIRE

A. AUSTIN MILLER

THE salient feature of the relief of South Wales is the contrast between mountain and coastal plain. The mountains of the coalfield terminate abruptly on the south, there is a sudden change in the form of the land, and their steep southern face looks down on the rich Vale of Glamorgan. This is, in reality, not a vale at all, but a region of dissected plateaux of low elevation, varying in height from 150 to 700 feet above sea-level, carved up by streams flowing in narrow but steep-sided valleys. The tops of these plateaux are characteristically flat or gently undulating and their margins, where they overlook the valleys, are generally well defined and even abrupt. They stretch from the mountains as far as the coast, where they terminate in long lines of steep cliffs, often rising sheer from the sea for as much as 250 feet, presenting some of the finest coastal scenery in Britain and displaying with striking clarity the geological structure of the region. The most westerly of the true mountains of the coalfield are the Black Mountains, terminating in Gareg-lwyd behind Swansea, and from this point westward the contrast between mountain and plain is less striking, but the coastal plateaux still retain their characteristic features and continue to contrast with such minor mountain masses as Mynydd Prescelly and Freni Fawr, whose irregular outlines rise from their flat foundations. The form and origin of the coastal plateaux, lying between mountain and sea, form the subject of this paper, and by an analysis of their relief and drainage the intention is to make a contribution to the denudation chronology of late Tertiary times and to reconstruct some of the missing pages of the geological record.

The plateaux have long been recognized as the product of prolonged erosion and the preponderance of opinion attributes this erosion to the sea. As applied to the plateaux below 450 feet O.D. there can be little doubt that this explanation is correct and meets the facts, but there is a well-developed plateau in Pembrokeshire and Carmarthenshire whose lower edge stands at about 600 feet O.D. and evidence will be adduced to show that it, at least, owes its form principally to subaerial erosion. An account[1] of some of these plateaux has recently appeared which confirms, in most respects, the independent findings of the present author and from which his interpretation differs only in matters of detail, at least as far as the lower plateaux are concerned. In view of this account it will be unnecessary here to present a complete description of those below 450 feet; attention will be confined to those features of the lower levels which have an immediate bearing on their relationship to the so-called 600-foot plateau and on the succession of denudation stages that it is intended to demonstrate.

THE PLATEAUX BELOW 450 FEET

That these are the products of erosion is unmistakeably shown by the lack of dependence of the relief on geological structure. They have been carved

[1] Kathleen L. Goskar and A. E. Trueman, *Geol. Mag.*, vol. LXXI, No. 844, October 1934.

out of a variety of rocks varying in age from Pre-Cambrian to Lias; in the cliff faces intense folding can often be seen, especially in the Palaeozoic representatives, while the plateau surfaces can be observed to truncate the upturned edges of the strata as smoothly as the surface of a board planed across the grain. In the Lias area of the Vale of Glamorgan the truncation is more difficult to demonstrate, owing to the virtual horizontality of the Lower Lias. Here the bedding planes of the slabby limestones have clearly influenced the form of the topography, but it can be shown, by considering a wide area, that though it has influenced it has not determined the plateau form which still truncates the bedding planes, though often at a low angle. Where inliers of Carboniferous Limestone project through the Lias the plateaux frequently pass from one rock type to the other with little or no change of form or altitude.

Plateaux have been described [1] at approximately 200 feet, 300 feet, 400 feet, and 600 feet, but, while these are perhaps the most frequently occurring altitudes, there is in fact practically no level at which well-developed erosion surfaces cannot be found somewhere in South Wales between the mountains and the coast. This is demonstrated by the folding map [2] which shows the relict portions of those plateaux which have survived subsequent dissection and demolition; contours have been added to show the heights at which they occur and, by extrapolation, the probable original form of the plateaux. The lowest well-defined plateaux are those of the Bosherston Flats at a height of about 150 feet, although wave-cut beaches occur in many places at still lower levels. These last however are seldom extensive and are of local significance only; the coastal plateaux proper lie between 150 feet and 450 feet.

From the Pembrokeshire portion of the map it can be seen that between these limits every 50-foot interval is represented somewhere by a plateau surface, and that in some cases (*e.g.* north-east of St. David's) the same relict portion of plateau has a gradual and continuous slope through a range of 150 or even 200 feet. Furthermore throughout the range from 150 to 450 feet there is no example of close juxtaposition of two plateaux at markedly different levels; no good examples, that is to say, of marginal demolition and cliffing of a high plateau by the sea that produced a lower one. It is true that a few localities on the ground provide indications of this process on a very small scale, but they are not sufficiently pronounced to appear on the map. Had the sea stood for any considerable period at any height between these levels it must have produced extensive cliffing of the emerged shore plane, the position of the base of the cliffs betraying the level of this sea. This is far from being the case; any features in the present topography that might be claimed as ancient cliffs are on a small scale and they occur moreover at different altitudes in different places. There appears to be no system in their arrangement and they cannot be correlated with any

[1] Rep. Brit. Ass. Norwich 1935. Sect. C.

[2] This reproduces, in a modified form, portions of a map which was drawn up by the author for the "Commission des Surfaces d'Aplanissement" of the International Geographical Union at its Warsaw Congress in 1934. It is based on the 1-inch Ordnance map, the plateaux being first identified in the field, their margins mapped by the "break of slope" as shown by the contour spacing, and finally, in certain critical cases, verified on the ground.

one fixed sea-level or even series of levels. They would appear to be local rather than regional phenomena and to result from local rather than regional causes; they probably represent stages in a continuous process of wave erosion on a continuously retiring shore-line, occurring whenever and wherever local conditions of wave-front direction in relation to the shore-line of the time were favourable to active erosion, or where geological structure and rock texture rendered the coast susceptible to wave attack. They may perhaps be compared to the unpaired terraces produced by a meandering river demolishing its own flood plain.

The second point to be emphasized is the fact that the altitude of the plateaux increases fairly steadily northwards towards the high ground of Mynydd Prescelly. It is probably truer to say that they rise away from the sea which, at the time of their formation, sent a wide arm up Milford Haven. With this proviso it can be seen from the run of the contours that low plateaux do not occur north or east of high plateaux; the original slope of the plateau surfaces was continuous from north to south or north-east to south-west. There is one important and significant exception to these broad general statements and that is the island of high plateau, at altitudes above 500 feet, lying between Milford Haven and the Taf-Towy estuary which will be dealt with later.

These relationships, which have been illustrated from Pembrokeshire, apply equally well in Gower and Glamorgan. In the latter area the elevation of the plateau surfaces rises from 150 feet on the coast at St. Athan to 400 feet on St. Lythan's Down, a distance of only about 4 miles, which is a much steeper slope than in Pembrokeshire. At 400 feet however the slope flattens and does not attain a height of 450 feet until some 6 miles to the north. Here there occurs the old cliff that marks the landward limit of the plateaux. This old cliff line can be clearly seen as an east and west bluff rising abruptly to heights of 800 and 900 feet, at the foot of which lie the villages of Margam, St. Bride's Minor, Llanharan, Llantrissant, and Pentyrch. The upper portion of the plateau here is however much obscured by drift, and has suffered considerable destruction by the encroachment and extension of the River Ely on the east and the River Ewenny on the west. It is significant that much of this dissection is pre-glacial and the relics of the plateau are not always to be found preserved beneath the drift which in fact extends down to the bottom of the valleys. This very considerable pre-glacial erosion is a point which must be borne in mind when estimating the age of the plateau features, for they must have been existent for some considerable time before the piedmont glacier from the South Wales mountains spread over the plateau region.

For the reasons adduced above it would appear that the whole series of plateaux between 150 feet and 450 feet was produced as the result of a continuous process, virtually uninterrupted and without any sudden changes such as would have given rise to marked breaks in the plateau surface.

There are three possibilities which, alone or in combination, might have produced the features observed:

1. continuous erosion of a beach or strand flat by wave action in a sea standing at about 450 feet above the present sea-level;

St David's
Haverfordwest
Milford Haven
Spittal
Boshe
350
300
400
250
200
450
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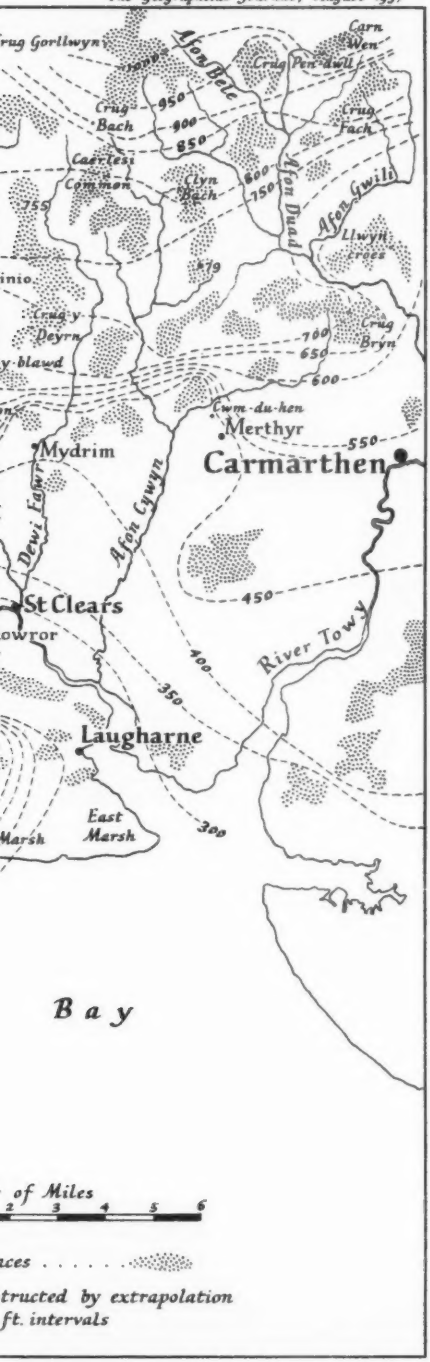
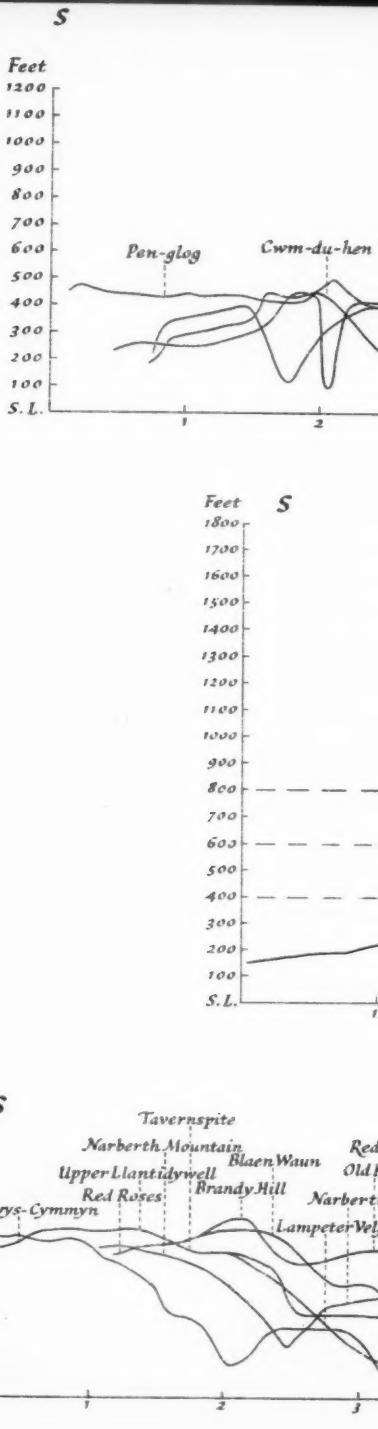


PEMBROKE & CARMARTHEN
Austin Miller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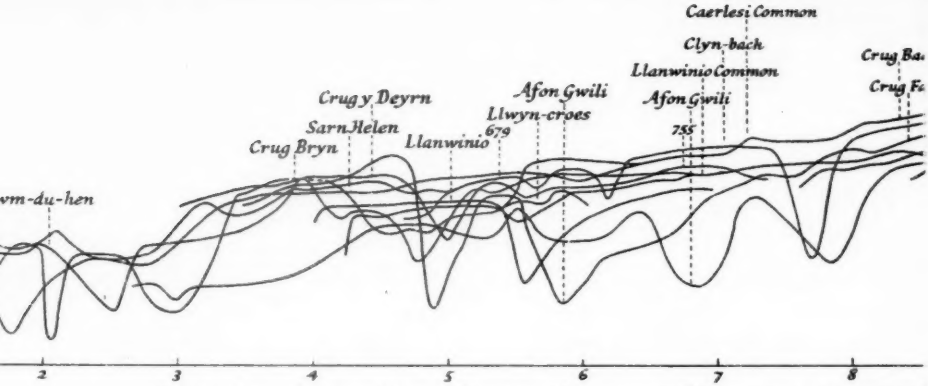

Fig.1. Superimposed interfluve profiles west of Lampeter-Carmarth

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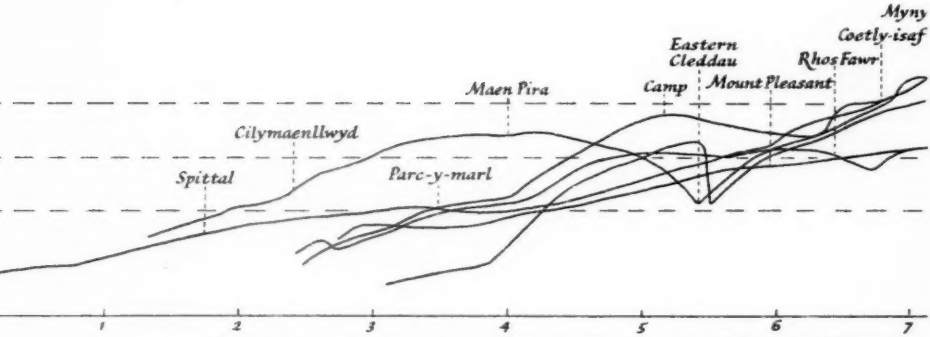


Fig. 2. Superimposed interfluve profiles south of Mynydd Prescelly.

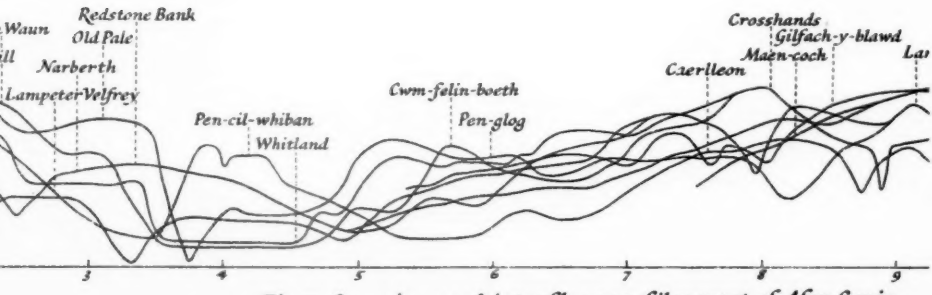
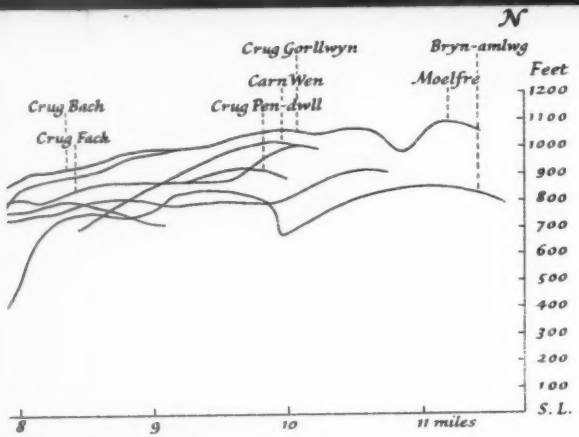


Fig.5. Superimposed interfluve profiles west of Afon Cynin.



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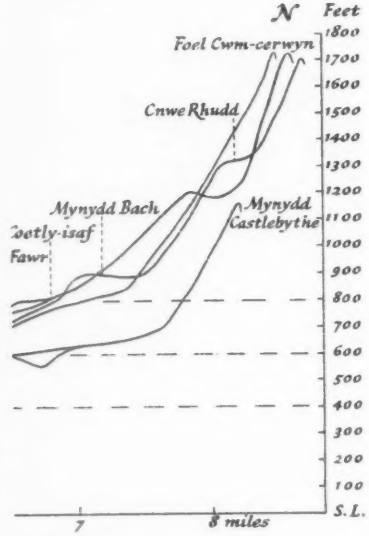

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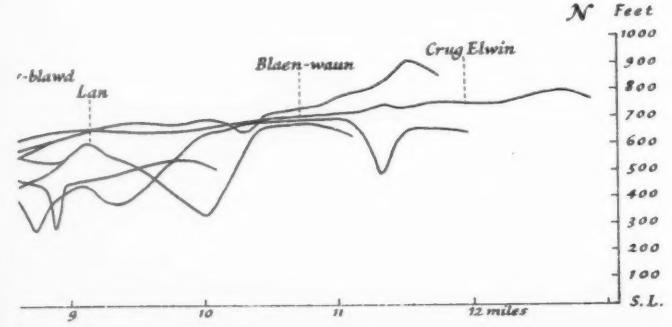

ynin.

2. wave erosion during an advance of the sea from a height of 150 feet to a height of 450 feet above present sea-level;
3. wave erosion during a withdrawal of the sea from 450 feet down to 150 feet above present sea-level.

There are two serious objections to the first hypothesis. It offers no explanation of the rarity of plateaux below 150 feet. The second objection lies in the slope of the plateau surfaces themselves. In Pembrokeshire this "beach" would have a slope of 300 feet in 24 miles, or 13 feet per mile; in Gower of 300 feet in 10 miles, or 30 feet per mile; and in the Vale of Glamorgan of 300 feet in 5 miles, or 60 feet per mile. The slope of a beach platform in the zone of breaking waves may be very steep, but over an extensive submarine peneplane it can only be very gentle, and while the slope in Pembrokeshire may be regarded as just within the bounds of possibility, that in Glamorgan seems altogether out of the question.

The second hypothesis, namely marine encroachment, would go far to remove the objection presented by the steepness of the slopes in Gower and Glamorgan. It is generally maintained that only by steady submergence can wave action extend far enough inland to produce extensive surfaces of marine abrasion. Douglas Johnson [1] denies this and considers there is no limit to the distance to which marine erosion can penetrate; but even if this is so the action in the last stages must be extremely slow, since the wide platform already produced robs the waves of most of their energy before they can reach the cliff line, and thus enormously reduces their effect. Ramsay,[2] when he first suggested marine planation as an explanation of the topography of South Wales, appreciated this and asked for "unlimited time" for the production of the plateaux. In any case there is no doubt that progressive submergence, by continuously exposing fresh areas to wave attack, considerably expedites the production of a submarine peneplane and allows it moreover to have a steeper inclination than would otherwise be the case.

We may now consider the third hypothesis, namely, wave erosion during retreat of the sea from 450 to 150 feet. In this case much would depend on whether the sea retreated steadily or spasmodically. If the former, the final product would not differ markedly from that produced by an encroaching sea. But if any halts occurred in the withdrawal the emerged portion of the shore plain would be attacked and eroded, with the production of a cliff. Dr. Trueman and Miss Goskar adopted this explanation and expressed the opinion that "such a surface as that developed in the coastal areas of South Wales could only have been produced by erosion as the land was rising, the lower platform having been cut so far as to remove all traces of a higher level at certain places, so that the lower platform may adjoin the higher hills of the inland areas." The illustration they quote in support of this is "the almost complete absence of the 600-foot plateau east of Carmarthen" which "leads to the coastal plateau at 400 feet abutting against the higher hills of the South Wales coalfield." This "600-foot plateau" will be dealt with in the second part of this paper, but I am of opinion that its relationship to the 400-foot plateau is essentially different from that existing between the 400-foot

[1] D. W. Johnson, 'Shore processes and shoreline development,' 1919.
[2] A. Ramsay, "Denudation of South Wales," Mem. Geol. Survey, I, 1846.

and the lower plateaux; consequently I regard the illustration as inapplicable to the case of the plateaux below 450 feet. It is admitted, as has been indicated previously, that there exist similar, though less spectacular, examples of the same phenomenon among the lower plateaux; but they are on a small scale and at inconstant heights, and do not appear to justify the recognition of important or long-maintained base levels during the formation of the erosion surfaces, nor to warrant a subdivision of the plateaux.

On the other hand, the predominant frequency of plateaux at the upper and lower levels, *i.e.* at 150 to 200 feet and again at 400 to 450 feet, seems to postulate periods of stillstand at these levels, and consequently more extensive planation, with the partial destruction and cliffing of higher plateaux. A similar state of affairs has been shown to exist in the coastal plateaux of Monmouth, east of the River Usk.[1] In any case it must be remembered that the plateaux have undergone considerable denudation since emergence, and old sea cliffs would inevitably have suffered serious degradation.

On the assumption, which appears to be generally admitted, that the coastal plateaux up to 450 feet are the product of marine erosion, it is obvious that the sea has stood about the 450-foot level and that it has retreated to the present level, laying bare, in the process, the old sea-floor. The question at issue seems to be the degree to which the features of the scenery are due to this later phase of marine regression, and how far, if at all, they are due to an earlier phase of marine advance. We cannot ignore the possible effects of the advance of a much earlier sea in Mesozoic times, at least for those plateaux which are carved out of Palaeozoic rocks.

Another informative line of evidence is provided by the drainage system. As the sea withdrew, a simple drainage system would be initiated on the emerged coastal plain, presumably one of north to south consequents directly across the Armorican grain of the country. Subsequents would develop along the soft layers, gradually cutting up the plateaux into relict portions, surviving longest on the interfluves which consisted generally of the harder rocks. With the evolution of the drainage, the pattern would become coarser as the smaller streams would be pirated by the more powerful. Without going into detail, it may be said that considerable evidence for it survives and that there are many small relict plateaux crossed by marshy depressions representing portions of a dismembered drainage system: an example is provided by the isolated flat-topped hill 4 miles south-west of Carmarthen. Furthermore the analysis of the drainage system shows a series of rejuvenations indicating grading to a progressively lower base-level. The lowest of these seems to be about 200 feet, and this, taken in conjunction with the extensive development of the lowest of the marine erosion planes at 150 feet at Bosherston, south of Pembroke, at Worms Head in Gower, at St. Athan, south of Cowbridge, and elsewhere, seems to indicate a considerable period of stillstand at about 200 feet. The rivers were graded down to this level and the beach was graded up to it. From this level the sea appears to have dropped abruptly, for although a few examples of wave-cut platforms occur at lower levels, they are never extensive. It fell to a level below that of the

[1] A. Austin Miller, "The entrenched meanders of the Herefordshire Wye," *Geogr. J.* 85 (1935) 160–78.

present day and the larger rivers graded their valleys down to it. The last movement has been a marine transgression which has in the first place drowned the main valleys and caused the main streams heavily to aggrade their lower reaches, and, in the second, given renewed vigour to the sea in its attack on the land, thus accelerating the cliffing of the shore-line and the demolition of the coastal plateaux.

The 600-foot plateau

From Carmarthen to Haverfordwest there extends a wide depression which may be called the St. Clears depression, continuing the direction of the Towy valley beyond Carmarthen, where that river makes an abrupt southward bend to enter the sea. The depression is drained eastwards by the River Taf, a subsequent stream, which turns abruptly south at St. Clears and shares an estuary with the Towy. Between this depression and the Teifi valley there rises a ridge of high land, known at its western end where it rises to 1700 feet as Mynydd Prescelly; it continues eastwards less prominently at an average altitude of over 1000 feet, except where broken by headward erosion of the tributaries of the Teifi, the Towy, or the Taf. It is on the southern slopes of this ridge that the erosion surface, which for convenience has been labelled the "600-foot plateau," is found. Actually 600 feet represents approximately its lower limit; it rises gradually northwards and it is difficult to define its upper limit, if, indeed, it has one.

The St. Clears depression is eroded in the soft Arenig and Llanvirn shales between Carmarthen and Whitland, while between Whitland and Haverfordwest it is mostly floored by mudstones of Bala and Lower Llandovery age. The Arenig grits, exposed in the core of the anticline and often faulted up, make isolated hills rising out of the depression, as for example just north of Llangynnog and east of Whitland Abbey, while the Llandovery conglomerate farther west similarly gives rise to hills at Llandewi Velfrey and Wiston.

The flanks of the anticline, Old Red Sandstone on the south and newer Silurian on the north, make the higher ground on which the 600-foot plateau is preserved.

As shown on the map considerable relics of this plateau survive on the interfluves between the deeply cut valleys of the southward-flowing streams draining to the Towy and the Taf, and the form of the surface may be reconstructed with a fair degree of confidence. It will be seen from the reconstructed contours that there is a gradual but constant slope to the south, at an inclination of about 50 feet per mile, from 1000 feet down to 600 feet, at which level the surface comes to an abrupt termination and the land drops suddenly to 400 feet.

These features are still more clearly shown in Fig. 1 (see folding plate) which shows the profiles along the crest lines of the interfluves. The crest lines are used for this purpose since the relics of the plateau will be best preserved thereon and least modified by subsequent erosion. The area shown is the country between the Carmarthen–Lampeter road on the east and the River Gronw on the west, to a depth of about 12 miles from north to south; each of the interfluve crest profiles is projected eastward on to a north and south vertical section. Since the slope of the plateau is due south and the

downward termination runs almost due east and west, the profiles are equal in length and their terminations superimpose almost exactly.

Three points are particularly noticeable from the profiles: the distinction of the plateau, at least in this locality, from the 400-foot plateau, from which it is separated by a clearly defined line of degraded cliffs; the uniform gentle slope of about 50 feet per mile; and the absence of any clear upward termination of the surface, which rises to 1100 feet and appears to pass insensibly into the plateau of Central Wales along the high ground bordering the Cothi valley to the north-east of Carmarthen.

But if the plateau is studied farther west where it abuts against Mynydd Prescelly a rather different relationship to the higher elevation is apparent. Fig. 2 (see folding plate) shows a set of interfluve profiles constructed in a manner similar to those in Fig. 1, and while there is the same clearly marked

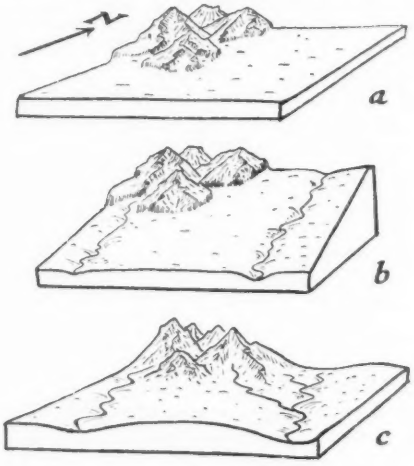

Fig. 3

distinction from the 400-foot plateau, there is, in contrast to the region to the east, a definite upward limit at about 800 feet. Here there may be recognized a feature resembling a degraded cliff-line above which the land rises steeply to the summit of Mynydd Prescelly with no indication of planation. This feature is sufficiently well defined to be noticeable on the ground; indeed it is quite striking as seen from the road north-east of Maenclochog. Thus the evidence of a shore-line at 800 feet in the west is contradicted by evidence of continuous planation up to 1100 feet only 10 miles away to the east.

Two possible explanations present themselves, but each raises a number of difficulties. The plateau might represent a surface, once more or less horizontal (Fig. 3, a), that has been tilted subsequently to the south (Fig. 3, b). In this connection it should be noted that the higher portions of the plateau in the east lie to the north of the Prescelly shore-line and would have been raised above it by the tilt. The idea of tilting an erosion surface, apparently

so recent in origin, and with so little deformation is not to be lightly accepted and would involve some very serious consequences. Some of these might be diminished if the surface turned out to be a stripped Mesozoic surface; but there is no evidence for this. Alternatively the surface might be of subaerial origin and not a platform of marine erosion at all. Mynydd Prescelly then appears as a monadnock arising from a normal peneplane (Fig. 3, c). This hypothesis appears more reasonable and derives some support from the form and height of the bluff at the foot of Mynydd Prescelly, and from the analysis of the drainage system.

The break of slope along the southern foot of Mynydd Prescelly

On closer inspection this may be seen to occur at an altitude which is by no means constant. At the foot of Mynydd Castlebythe, at the western end of the range, the plateau, well seen on the flattened spur of Rhos Fawr, terminates at about 650 feet; at this point the slope abruptly steepens uphill to the summit at 1137 feet. Four miles farther to the east and about a mile north of Maenclochog the break of slope occurs at 800 feet. Four miles farther east again, in the head of the Waun Isaf valley, it appears to be at 700 feet or 750 feet. In the face of this irregularity of altitude the feature cannot be regarded as a synchronous cliff-line marking the farthest limit of submergence, though admittedly it might be produced, section by section, by an encroaching or retreating sea.

The drainage system of the 600-foot plateau

A simple inspection of the valleys that dissect the plateau surface is enough to show that they have been rejuvenated. An upper valley form can generally be recognized—mature, open, and gently sloping—into the floor of which the present valleys are deeply cut, the line of junction between the two facets being often clearly discernible. But the rejuvenation, so apparent in the gorge-like cross-section, fails to appear in the longitudinal profile of most of the streams. It seems to have advanced upstream to the heads of the valleys, giving the middle and upper reaches an unbroken, graded curve (see Fig. 4). Only in one or two valleys is the break of gradient detectable, as for example in the valley of the Afon Wern, a headstream of the Eastern Cleddau draining the south-eastern slopes of Mynydd Prescelly, which preserves, down to 600 feet, a little of the earlier mature drainage. The Afon Cynin with its tributary, the Afon Asen, shows a similar form; but in no case is the upper reach sufficiently long to permit of any calculation of the base level towards which it is graded.

Much farther downstream, and clearly of a later date, there occurs in many valleys, particularly in the Afon Cynin and Afon Cywyn, a second marked rejuvenation which is invading and demolishing the middle graded reach. This middle reach is sufficiently long and well enough graded to permit an assessment, by extrapolation, of the base-level to which it is graded (Fig. 4). Both profiles are graded to a level just below 200 feet, at which the curve flattens to horizontality. This points to a prolonged stillstand with the sea-level about 200 feet above that of to-day. From that height the sea has fallen abruptly to a level below the present one, and has initiated the last rejuvenation.

We may now return to the upper rejuvenation and examine the evidence provided by the cross-sections of the valleys. It has been pointed out that these present a valley-in-valley form, the upper valley mature, the lower

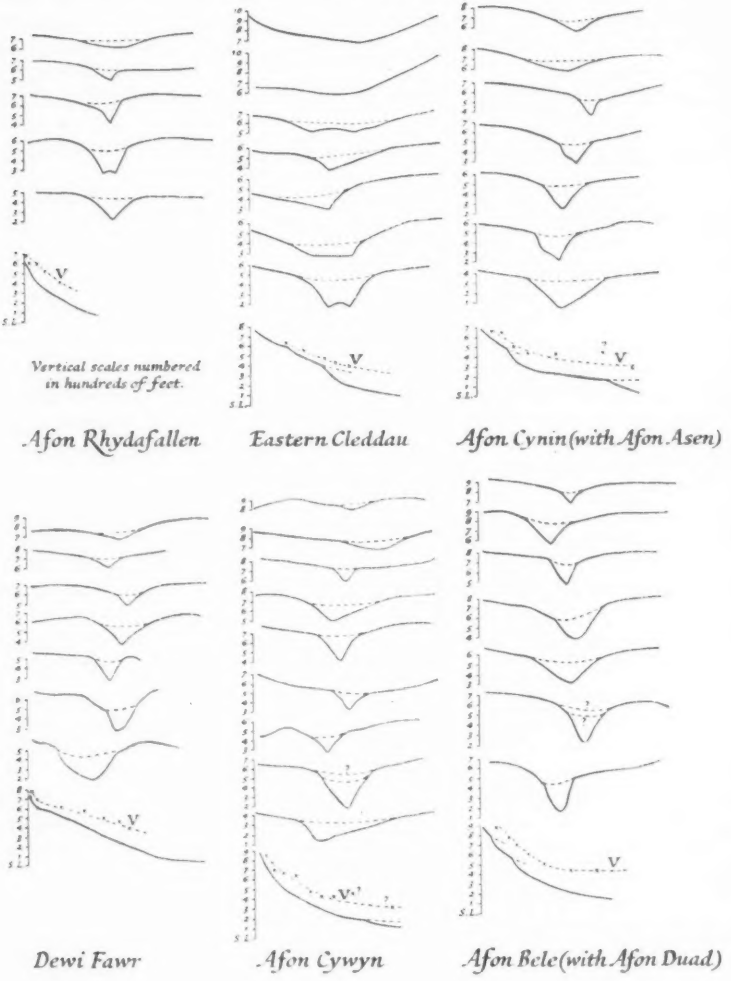

Fig. 4

youthful. Fig. 4 shows a number of cross-sections drawn at frequent intervals across the valleys. All show strongly marked shoulders to which the entrenchment of the later cycle has reached. From the portions above the shoulders it is possible to reconstruct the shape of the former valleys and to determine

the altitude of their floors at each point. By joining the points so determined it is then possible to reconstruct the thalweg of the pre-rejuvenation stage. The original cross-sections were drawn on the 6-inch scale, the information of the contours being supplemented by the use of spot heights and the line of section being chosen as far as possible so that a number of spot heights were available at critical places. The general agreement of the results and the way in which the points fall on or near a graded curve suggest that the conclusions are valid.

In using these curves to determine the base-level to which they are graded, an initial difficulty is presented by the fact that only three of them flatten to horizontality in their lower reaches: the Afon Bele (with Afon Duad) is graded to 425 feet, the Afon Cynin (with Afon Asen) to 350 feet, and the Afon Cywn to 350 feet. The other three maintain a steady fall as far as they can be determined, and the question arises as to how far they are to be prolonged, that is, as to the position of the shore-line at the time of their production. Now in view of the general agreement of the first three in being graded to a base-level of 350 to 400 feet, it might be productive of results if the relation of the last group to the 400-foot shore-line were examined. This shore-line can be determined with some degree of certainty; it is shown by the crowding of the contours on the map, and the point at which the streams cross this shore-line is shown on Fig. 4 by the symbol V. It is noticeable that the reconstructed profiles all cross this line at 400 feet, and it seems reasonable to conclude that the earlier drainage of the 600-foot plateau was graded to the 400-foot sea-level, and was contemporary with the formation of the 400-foot marine platform that lies to the south.

The evidence provided by the analysis of these valleys may be summarized as follows: a mature drainage system characterized by wide and open valleys existed on the 600-foot plateau before rejuvenation occurred. Such a valley system could only have been achieved in the late stages of the geographical cycle. The conclusion appears inevitable that the form of the plateau with its gently swelling interfluves and its subdued relief was produced during the subaerial cycle to which the valleys belong. The valleys were graded without break to a sea-level of about 400 feet, although this cannot be established with accuracy, and the interfluves would terminate in headlands with low cliffs.

Rejuvenation then occurred as a result of a fall in level of the sea from 400 feet to 200 feet and thereafter began the entrenchment of the rivers into the floors of their mature valleys; this entrenchment can scarcely have been very remote in time since the new valleys are steep-sided and the lateral erosion of the slopes has not proceeded far enough to demolish the upper and older valley form. On the other hand the duration of this stage was sufficient to permit of the production of a completely graded longitudinal profile without breaks or irregularities, and the headward regression of the graded curve has proceeded almost to the source. The base-level at this stage stood at 200 feet.

This second stage, marked by the grading of the rivers to the 200-foot level, is clearly distinguished from the last stage represented by the lower break in the longitudinal profile. As the sea-level fell again it caused the streams to entrench themselves into the coastal plateaux, but the entrenchment has not proceeded very far; this cycle was still in its infancy when interrupted by the final marine transgression.

The Brandy Hill–Tavernspite plateau, an outlier of the 600-foot plateau

To the west of the Towy estuary, behind Pendine and Marros, there rises a plateau extending over an area of about 30 square miles, at an average elevation of 550 to 600 feet, the highest points being Brandy Hill (677 feet) and Middleton Hill (675 feet). The plateau is developed mainly on the outcrop of the Old Red Sandstone marls, but extends northwards on to the Llandovery grits and mudstones on Old Pale Hill, and southwards on to Carboniferous Limestone and Millstone Grit on Marros Mountain. To the north lies the valley of the Taf carved along the strike of the Lower Palaeozoic rocks of the St. Clears anticline, while to the south the land falls steeply to the synclinal hollow occupied by Coal Measures running from Saundersfoot Bay to Cresswell River and Milford Haven. Where it meets the sea between Amroth and Pendine the edge of the plateau is steeply cliffed on the south, and falls from Marros Beacon (499 feet) to the sea in little more than a quarter of a mile. Eastward the line of steep seaward slope with cliffs is continued nearly to Lougharne, though now separated from the sea by low-lying West and East Marsh, fringed by the sandhills of Lougharne Burrows.

The surface of the plateau is gently undulating, and even where it rises above 650 feet it does so in gently rounded hills. Its margins however are undergoing rapid demolition by the headward erosion of a number of streams which are deeply entrenched in steep-sided coombe-like valleys. These are perhaps most striking along the seaward margin from Lougharne to Saundersfoot, but the right-bank tributaries of the lower Taf between Whitland and St. Clears are scarcely less spectacular.

Now it is clear from the map that this plateau does not conform to the general behaviour of the coastal plateaux described in the first part of this paper. It is too high and it lies too far south. It must be regarded as an alien surviving element offering successful resistance to the seas which produced the coastal plateaux at lower levels in much the same way as the Ridgeway Conglomerate, extending from Penally to Pembroke, defied the attacks of the sea that was producing a wave-cut platform at 200 to 250 feet all round it. Its form, its undulating relief, and its height ally it more clearly with the so-called 600-foot plateau, from which it is separated by the Taf valley, eroded along the St. Clears anticline. It is not however a direct continuation of this surface, for it does not maintain the same slope. If the slope of the 600-foot plateau is projected across the Taf valley it would intersect the Brandy Hill plateau at about 200 feet. If therefore the correlation of the Brandy Hill with the 600-foot plateau is correct, this surface must either have been warped up to the south, which seems unlikely and is unnecessary, or it must have had an original down-curved form with slopes towards the St. Clears depression from both directions. Thus it seems that the line of weakness of the St. Clears anticline is a feature which had already been picked out by the drainage at the time of the 400-foot sea-level.

Both on the ground and from the map it is a striking and significant fact that the southern edge of the 600-foot plateau on the northern side of the St. Clears depression is cliffed both to the east of the Brandy Hill plateau, between Mydrim and Merthyr, and again to the west of it at the foot of Mynydd Prescelly, but not in the intervening space. From this it

would seem that the Brandy Hill plateau operated as a barrier and breakwater against the 400-foot sea, which succeeded in invading only round its flanks. Whether the sea ever succeeded in circumventing this barrier and converting it into an island is difficult to decide with certainty. A number of hills rise out of the St. Clears depression to heights of about 400 or 450 feet, but their surfaces are not remarkably flat and they cannot be ascribed with any certainty to marine planation. Such are Crinow Hill (414 feet), Llandewi Hill (461 feet), Pant-y-Crug Hill (495 feet), and the hills just south of Mydrim (459 and 410 feet) which owe their preservation to the outcrop of Asaphus Ash.

Fig. 5 (see folding plate) shows a number of projected crest-line profiles constructed in the same way as those shown in Figs. 1 and 2, the area treated lying between the Afon Sien, a tributary of the Afon Cynin on the east, and the Eastern Cleddau on the west: that is, the strip of country protected by the Brandy Hill–Tavernspite plateau. The line of sections is continued farther south than in Figs. 1 and 2 so as to include this plateau, whose margin at about 500 feet can be recognized at the southern end of all the profiles, while the 600-foot plateau is equally discernible in the first five miles from their northern limit. Its southern edge is not however a cliffed face as it is farther east and west, but shows a gradual fall towards the St. Clears depression. This slope, which is apparent on practically all the interfluves, is about three miles long and has an average gradient of about 150 feet per mile—about three times as steep as the slope of the 600-foot plateau itself, but in no way resembling a degraded cliff. For a time the Brandy Hill plateau must have resembled the Gower Peninsula of to-day, a hilly peninsula joined to the mainland by a low-lying neck of land, the mainland to east and west being bordered by cliffs, as is the coast at Briton Ferry and Aberavon to-day.

Summary and conclusions

The so-called 600-foot plateau owes its form mainly to subaerial erosion, having been peneplaned by a system of rivers graded to a 400-foot sea-level. This does not preclude the possibility of the drainage system having developed on an emerged surface of marine erosion of an earlier date.

The sea-level remained constant at about 400 feet for a considerable time, producing a widespread erosion surface and cliffing the coast-line which lay to the north.

The sea then withdrew gradually southward, the level falling without notable interruption to about 200 feet, forming in the process an emerged coastal plain with a gradual and continuous seaward slope. Meanwhile the rivers extended their courses over the emerged coastal plain and began to cut it up into isolated plateaux. They deepened their valleys in the lower reaches of their former courses to grade to the new 200-foot sea-level.

The sea fell fairly abruptly to a level below that of to-day. It withdrew considerably beyond the present shore-line, but regained some lost ground by eroding and cliffing the emerged coastal plain. A new cycle of erosion began on land and encroached a considerable way up the valleys.

The sea advanced again to its present level, drowning the forests along the coast and invading the valleys to produce estuaries. Marine erosion was rejuvenated and the process of cliffing was accelerated.

BRITISH CANADIAN ARCTIC EXPEDITION, 1936–39

WE have received, through the courtesy of Mr. Ian Cox, an account of the work of the British Canadian Arctic Expedition, led by Mr. T. H. Manning, from August 1936 to February last. Mr. Manning and his four companions, Messrs. G. W. Rowley, R. J. O. Bray, P. Baird, and Dr. R. Keeling, left Fort Churchill for Coral Harbour, Southampton Island, on their specially built whale-boat, the *Polecat*, at the end of June 1936. On August 22 the Canadian Government ship *Nascopie* arrived at Coral Harbour with their stores, and another member of the party, Mr. P. Bennett, Dr. Keeling leaving with her when she sailed on the following day.

After arranging the stores and loading the whale-boat two parties were formed, Manning and Bennett to sail the boat round Southampton Island through Roe's Welcome, and Rowley and Baird to visit Coats Island. It was arranged that they should meet at York Bay, at the northern end of Southampton Island, on September 20.

Manning and Bennett left Coral Harbour in the *Polecat* on August 26. South Bay had packed with ice after the departure of the *Nascopie*, but the *Polecat* got through without difficulty, and reached the mouth of Boas River, in the Bay of God's Mercy, two days later. Here Bray, who had been collecting birds, joined them. This area is one of the two known breeding grounds of the blue goose, and he had succeeded in obtaining a very complete series, and good specimens, of rare gulls. Some difficulty was experienced here from the tides, which run out for several miles, but on September 1 they reached Cape Kendall and determined its latitude and longitude, and three days later obtained another fix 40 miles to the north. On September 7 they anchored in a small bay half-way up the west coast. The boat grounded as the tide ebbed—this was the last of the spring tides—and it was not until September 14 that the *Polecat* was refloated. The following day, some miles south of Cape Munn, they encountered a heavy snow storm and were obliged to run inshore to seek shelter. A change of wind then caused the *Polecat* to drag her anchors and to drift ashore. They were not successful in refloating her and she was badly swamped until the wind changed again. This change however packed the ice inshore, and two days were spent in waiting for it to shift. Eventually, after four hours' hard work with axe and pole, they made their way out to open water. On September 21, while Bray and Bennett were ashore at Cape Munn observing, a storm arose and Manning was obliged to set the canoe with extra equipment loose. Most of its contents however were later recovered from the beach. York Bay was finally reached on September 24. Here they were joined on the following day by Baird and Rowley.

The latter had left Coral Harbour towards the end of August with a party of ten natives, who proposed to hunt caribou on Coats Island, in their two motor boats. After some delay, caused by heavy weather in South Bay, they reached the middle of the north-west coast on September 2. The island abounded in polar bears, but few deer were seen, so they moved southwards. Most of the party were suffering from severe colds, probably brought by the *Nascopie*, so that they were compelled to remain at one camp on the shore for

eight days. The island here is low-lying, with a very shoal coast. When sufficient men had recovered it was time to return to Coral Harbour, which was reached on September 13.

Strong winds blew for the next few days, but a start was made for York Bay as soon as possible, in company with two natives and twenty dogs, twelve of which had been bought for the expedition. The journey of 100 miles took eight days, as detours were necessary to avoid the then unfrozen lakes, and the sledge had to be unloaded to cross two streams.

The re-united party made some distance northwards through the ice in York Bay on September 26, but that evening discovered that the canoe, containing their tents and other important equipment, had broken loose, and was lost. Rough weather and difficulties with the motor, due to the cold, delayed the voyage into Frozen Strait; the northern shore however was reached on October 2. As the season was now far advanced, and it was improbable that the *Polecat* could reach the post at Repulse Bay and return before the strait was frozen over, it was decided to beach her and to continue the journey by land. A sledge was put together from a broken mast and some spars. The journey was difficult, for the sea-ice had not formed, the snow was soft, and without the tents they had to build snow shelters at night. In these conditions the journey of 60 miles took nine days.

At Repulse Bay, Mr. Brown, the district manager of the Hudson's Bay Company, kindly put at their disposal the trading post of Revillion Frères, which had been closed down on their amalgamation with the Company. Here preparations were begun for the winter journeys; sledges, dog harness, and skin clothing were made; and the equipment, cached on the journey in, recovered.

As food for the dogs was limited, it was decided that Bray and Rowley should take one team to the Inglulik district of Melville Peninsula. They set out on December 21 and were accompanied by Manning beyond Gore Bay. From Eskimo reports, they should have reached their destination early in February. The other members of the party made shorter trips, surveying Repulse Bay and the country to the east.

On February 4 Manning and Bennett left to take a mail to Chesterfield Inlet. In the fine but cold weather there was a thick haze of frost on the snow, and the going was heavy. Their route lay overland to the post at the head of Wager Inlet, and thence *via* Daly Bay and the coast. At Wager Inlet, a sledge having been damaged and four dogs lost, Manning decided to continue alone, and to leave Bennett to survey the Inlet. Manning's thirteen days' journey to Chesterfield was uneventful. He returned to Repulse Bay along the Hudson Bay coast.

All the members of the expedition are well; with the exception of Manning they will be returning this year. He is planning a journey to Baffin Island this summer, and, if possible, to King William Island.

NORTH AFRICA

LE PASSÉ DE L'AFRIQUE DU NORD: les siècles obscurs. By E. F. GAUTIER. *Paris: Payot*, 1937. 9×5½ *inches;* 458 *pages; illustrations and maps.* 40 *fr.*

WE know the history of North Africa in great detail during the centuries while it was Roman and Christian, from Sallust to Saint Augustine. Then after an interval of five or six centuries we have the Arab historians of Maghreb, from El Bekri to Ibn Khaldun. But the world these Moslem writers depict, while it clearly resembles North Africa as we find it to-day, is utterly different from that of Roman times down to the fourth century. Professor Gautier has set himself to solve how this immense change took place. Ten years ago he published 'L'Islamisation de l'Afrique du Nord,' which has been out of print for several years. The present work is much more than a revision, for new research has greatly widened the field of study. Pre-history and proto-history supply chapters of great interest. The illustrated rock engravings of prehistoric men and beasts are a revelation in themselves.

North Africa has never had a name of its own. The name given by the Arabs "Maghreb," *i.e.* the West, is a natural one from the point of view of people and influences coming from the Levant. It covers all North Africa lying west of Egypt, and is the country of the Berber race, which has never achieved a separate national existence. Geographically it justifies the Arab expression "Djezirat el Maghreb," the Island of Maghreb, for it is surrounded on all sides either by sea or by the desert. Consequently while the Maghrebin is the most backward of the white races of the Mediterranean, changes are all the more rapid when invasion occurs. The ancient wealth and resources of this dry and salty country are explained by the author without recourse to the easy theory of climatic changes. The soil of "the granary of Rome " is proved to give an average yield of only one quarter of that of France. If Africa supplied daily bread to half the population of ancient Rome, it was not because it grew more, or even as much, wheat per acre as Europe, but because wheat was a convenient form of tax.

The author considers that too little attention has been given to the thousand years of continuous Phoenician and Oriental influence. The earliest Phoenician colonies on the Mediterranean coasts dated from 1150 B.C. and Carthage was destroyed in 146. It is only of the last century of Carthaginian rule that we have historical information. Of its prior evolution we have little evidence except the 'Periplus' of Hanno, and of this merely a Greek translation. The author holds that much misconception is due to the translator. The name *Periplus* suggests what later Portuguese writers called a *portolan*: a guide-book of ports for the information of merchants and navigators. But Hanno was not an explorer. He was a Suffete, a High Commissioner on a tour of inspection in the well-established domain of Carthaginian trade and colonization. The Carthaginian Senate rightly honoured the work of a great official by setting up a bronze tablet in the Temple, but they did not disclose the secrets of their policy and trade for the benefit of their rivals. The river Chretes of the 'Periplus' the author identifies with the River Senegal; the island of Cerne at its mouth, corresponding closely to modern St. Louis, he regards as the depot from which he believes the Carthaginians navigated the river as far as Kayes and the tributary river Faleme, where are the long famous gold mines of Bambuk: a piece of information much too important to be published in the 'Periplus.' With greater certainty he identifies the "burning mountain," "the chariot of the gods" with the Cameroons, the "Mungo ma Loba" of its present inhabitants. With much probability the

author ascribes the art of the Benin bronze-workers and the beads now being dug up in the Bauchi fields to Carthaginian trade and the search for tin. He believes that the penetration and vitality of Carthaginian civilization is to be gauged by the fact that the Punic language was widely spoken in Saint Augustine's day, and that Procopius records it as still spoken by the country people in the sixth century A.D. Are we to regard the history of North Africa as a duel between Western and Oriental influences, Latin and Christian Africa, great though its achievements were, being a mere episode of a few centuries between two millenniums of the Orient?

The author finds valuable demographic evidence in the fauna of ancient Maghreb. The presence of elephants throughout the Roman age and the export of wild beasts to fight in the circus games must mean that the population was small and that there were vast areas of uninhabited forests which later became cultivated lands or were peopled by nomadic pastoral tribes. Carthaginian Maghreb must have been three-quarters empty of people. The Roman age of peace and good government peopled the empty lands. Why did not this solid Roman work of civilization enable Latin and Christian Africa to survive?

The author finds the answer in the introduction of the camel. He gives chapter and verse for their first appearance in Julius Caesar's day, and gradual multiplication until the Roman general Ammianus Marcellinus was able to requisition four thousand camels in Tripoli in A.D. 363. Among all the great benefits conferred by Rome on North Africa the fatal gift of the camel brought her ruin. While it extended North African trade into the Sahara and the Sudan, it also gave an immense impetus to the strength and numbers of the nomad tribes, who in every age have been robbers and destroyers. From the sixth century onwards the history of Maghreb becomes more and more a struggle between the civilization of the towns and the savagery of nomads, between the sedentary peasants who cultivated the soil and the tent-dwelling pastoral tribes who found buildings useful merely to supply stone props and wood fuel for their kettles.

Ibn Khaldun tells us of these tribes in his history of the Berbers, and the author praises him as the only one of many Arab writers who is truly historical in his methods, and in his critical ability to distinguish important from trivial facts. Actually Ibn Khaldun treats the great Zenaga tribe as distinct from the Berbers, or at least as speaking a different dialect. They were nomads living in tents with many horses and camels, robbing the peasantry and repulsing all regular government. He divides the Berber tribes into those of Botr, who are almost synonymous with Zenaga, and the Beranes group which includes the Ketama and the Sanhaja or Zenaga, whose descendants are the modern Kabyles. Botr and Beranes are names derived in Arab fashion from a more or less fictitious genealogy. The descendants of the Botr call themselves Arabs and sincerely believe themselves to be of Arab race, but the author considers their belief to have little foundation when the facts of the Arab conquest are examined.

The Arab attacks began in A.D. 641. The Byzantines were defeated in 647. The great raid of Okba to the Atlantic coast took place in 683, the second great expedition in 708, and the invasion of Spain in 711. The invasion continued for seventy years, during which the Arabs suffered several crushing defeats and finally retired to Egypt and Cyrenaica. In spite of this tremendous and successful resistance by Africa and the fact that in the ninth century a Berber tribe, the Ketama, reversed the process and established the Fatimid dynasty in Egypt, Maghreb nevertheless became Moslem and is to-day largely arabized. The author suggests as an explanation of this surprising result that the Berber race has never developed a sense of nationality, but has remained in the clan

and family stage of political development. Perhaps also latinized Africa was still Punic at heart and found it easy to accept a fresh inrush of Oriental religion and culture.

The second great Arab invasion brought more serious results than the first. The Hilal and Soleim Badawin tribes were transported as a punishment from their home in northern Arabia to the banks of the Nile. Their presence was undesirable, and in 1051 they were invited by the Fatimid ruler to move westwards against the Sanhaja Sultan at Kairouan. For two centuries the Ketama and Sanhaja sultans had held their nomad tribes in check. The coming of the Badawin turned the scale. For the cities and settled populations of Maghreb it was a catastrophe, the end of their world. Centuries of destruction followed, not only by the invading Badawin, but by other plunderers let loose by the collapse of settled government.

The first Arab invaders were armies of soldiers. Where they settled they married Berber women and brought up mixed families. The second invasion was that of the whole tribe bringing their women and children. Their actual spread was slow and was still incomplete when Ibn Khaldun wrote in 1400. There is evidence that the Hilal and Soleim were not in themselves very numerous. The author suggests 200,000 as a probable maximum. Centuries of war could not have permitted any great multiplication of them or any wide substitution of Badawin for Berber population. Probably the Badawin was merely the leaven in the Berber nomadic dough. Ibn Khaldun shows that Maghreb in his day was still essentially a Zenaga country. It is typical of Maghreb history that this great Zenaga tribe after centuries of tumult seems to have disappeared without a trace. The author concludes that those who now believe themselves to be Arabs, and who claim names derived from the Hilal and Soleim invaders, are in fact descendants of the Zenaga. In the Middle Ages nomad Berbers hated and fought peasant Berbers. Now we have nomad Arabs hating and opposing Kabyle Berber peasants. The eternal opposition is that of the nomad to the sedentary peoples. E. J. A.

PEARY'S JOURNEY TO THE POLE

Notes on the Review of 'Peary' (*The Macmillan Co.*, 1936). *Geographical Journal*, March 1937

ON April 29 last the President received from Messrs. Hugh C. Mitchell and Chas. R. Duvall, of the Geodesy Division, U.S. Coast and Geodetic Survey, Washington, D.C., a note dated 19 April 1937 submitted as a correction to the review of Professor Hobbs' life of Peary in the *Journal* for March 1937. The President referred this manuscript to the Publications Committee, who considered it at their meeting on May 31, and referred it to the reviewers, asking them to prepare a note embodying any reply they would wish to make if the note were published. A copy of the reply thus prepared by the reviewers was by direction of the Committee sent to Messrs. Mitchell and Duvall on June 18 with a letter saying that the Publications Committee would be very willing to publish their note in the *Journal* but would be obliged to allow the reviewers the opportunity of reply. To this Messrs. Mitchell and Duvall answered that after carefully considering the papers they were more convinced than ever that it was essential in the interests of truth for their correction note to be published. The note and the reviewers' reply are accordingly printed here.

I. Note by Messrs. Hugh C. Mitchell and Chas. R. Duvall

The March number of the *Geographical Journal* for this year carried a review of the life of Rear-Admiral Peary by Dr. Wm. H. Hobbs ('Peary,' The Macmillan Company, 1936). In this review, published over the initials "A. R. H." and "J. M. W.", appear statements and innuendoes concerning previous reductions of Peary's North Pole astronomical observations which make it incumbent upon us as authors of those reductions, and upon the *Geographical Journal* as a highly responsible publication, to correct the errors committed by the reviewers, and to direct the reader to a full discussion of the material under consideration: one, incidentally, which has been before the public for many years.

Because of our connection with the computations of Peary's observations we will confine our attention to that part of the review concerned with the astronomical observations made on the polar trip, refraining from taking more than passing notice of the fact that the book as a whole, a fascinating word picture of a great man and a very readable piece of literature, has been neglected for a discussion of a long-since settled controversy.

The reviewers appear to have formed and expressed opinions without a complete knowledge of easily available facts. Had they but consulted the paper cited by Dr. Hobbs as the source of Appendix C, rather than relying upon that excerpt, clearly marked "(*Reprinted—in part—from Acts of the 10th International Congress of Geography, Rome*, 1913)", they surely could not have written so misleading an article. No difficulty should be encountered in obtaining access to the "Rome paper," published under the title "To Students of Arctic Exploration," as part of the proceedings of the Tenth International Geographical Congress (pp. 682–716), also as a separate in 1914, and more recently (1927) reprinted and distributed by the National Geographic Society. The references in the following paragraphs are to the pagination of the original publication, which is the same as in the 1927 reprint. The pages in the 1914 reprint are numbered from 1 to 35.

Criticizing the reduction of the observations as given in Peary's own book, 'The North Pole,' the reviewers state that these observations would have been better treated as "sights giving position lines," instead of being worked up as meridian sights for latitude. As a matter of fact, they were properly reduced by the field party, since they were sights taken on the sun at local noon of the meridian of travel. The positions derived were, of course, subject to the errors of the astronomical observations and to errors arising from failure to hold the course of travel accurately. Mitchell and Duvall, with ample time and facilities at hand, adopted precise mathematical methods in their computations of the position of Camp Jesup, but in reducing the observations of Marvin and Bartlett they used the same method as was used in the field, the positions obtained being subject to the errors noted above. The changes in latitude which would result from off-meridian distances will be found in a table on p. 695 of the Rome paper. A discussion of errors due to the use of sextant and artificial horizon appears on pp. 710 *et seq.* of the same paper. It should be remarked here that *all* of the astronomical observations taken by Peary and his assistants on the polar journey are given in the Rome paper.

In the course of their article A.R.H. and J.M.W. see fit to include (p. 257) such parenthetical references to the time used in reducing the astronomical observations as: "(Doubtless on good authority)", and "(on no stated authority)". The authority for the time used is found on pp. 689 and 690 of the Rome paper, and includes chronometer comparisons, watch corrections and rates, and checks thereon.

A rather vague criticism of Mitchell's calculations as an "elaborate" and "complicated" way of solving the problem, and as looking "rather ill-founded" until one understands them, is to be found at the bottom of p. 257 of the *Journal*. This serves as a sort of introduction to the assumption that Mitchell and Duvall were unacquainted with the graphical solution set forth on p. 258. That such an assumption is not justified is shown by the following excerpt from the Rome paper (p. 688): "We have then the position of Camp Jesup determined by that method, the graphical solution of which is known to all navigators as the Sumner Method, a method of position determination well adapted to practical navigation."

The more lengthy but mathematically accurate methods employed by Mitchell and Duvall were preferred over the graphical solution because there were obtained thereby (to quote the Rome paper, p. 696) "safe and satisfactory checks on the mechanical operations of the computations as well as on the theory of the problem."

But all the foregoing appear as mere petty inferences when the reviewers presume (p. 258) that "One may be allowed to say that Duvall's calculation, by a different method, determining the hour angle of the sun from its observed altitude, arrives at Mitchell's results only because it starts by adopting his latitude within 0′.06; without that advantage it would have produced something very different." Now, one may assuredly *not* be allowed to make such a statement, for the simple reason that it is altogether untrue. Not only was Duvall's computation entirely independent, but the method used by him could not possibly yield a different result from the one which he did, in fact, obtain. Once more we quote the Rome paper (p. 696):

"Mr. Duvall, whose computation is placed immediately after that of Mr. Mitchell, used the *s* formula of spherical trigonometry, and by means of a series of approximations deduced a value for the latitude which satisfied the conditions imposed by the problem."

"The problem is this: Two spherical triangles are considered; these triangles have for common vertices the pole and the zenith at Camp Jesup. The third vertex of each triangle is the position of the sun at the time of observation, namely, one is the position of the sun at $6^h\ 30^m$ a.m., April 7, 1909, and the other its position at $12^h\ 30^m$ p.m. of the same day. In these triangles we have the two sides corresponding to the two zenith distances (observed); the two sides corresponding to the two values of the co-declination of the sun at the two times of observation; and the difference of the two angles at the pole, which is equal to 90° and is the difference of the two hour angles of the sun. We have the further condition that the third side of the two triangles is common to both, and is equal to the co-latitude. By a series of approximations Mr. Duvall determined a value for this third side, the co-latitude, which would complete the two triangles and give values for the two angles at the pole differing by exactly 90°. The problem proved a determinate one, the difference in the two angles at the pole being very sensitive to small changes in the assumed co-latitude. Only the final approximation of this computation is shown here."

In short, the review as a whole is somewhat misleading and negative, with the possible exception of the reduction of the polar observations by the usual graphical method. The result of this graphical solution is necessarily in practical accord with the position of Camp Jesup as determined by us.

HUGH C. MITCHELL.
CHAS. R. DUVALL.

II. Reply by the Reviewers, A.R.H. and J.M.W.

Messrs. Mitchell and Duvall do not dispute our belief that the watch-times of Peary's observations were not recorded, and that the times $6^h\ 30^m$ a.m. and $12^h\ 30^m$ p.m. assigned to the means of the third and fourth groups of four altitudes each are only the rough times at which it was intended to take them. It follows that the "elapsed time" between the means of these groups is not known within a good many minutes. Consequently the solution of Mr. Mitchell, by the method of differences of altitude and the elapsed time "looks a little ill-founded" until one remarks that the trigonometrical method is equivalent geometrically to the Sumner method, and that local times near the pole are of little account or importance. Moreover, since the declination of the sun about April 7 is changing by nearly a second of arc in each minute of time; since no one has claimed that the mean of either set of altitudes is likely to be correct within a number of seconds of arc; and since the corrections for refraction at low altitudes above an ice horizon cannot be relied upon, it is not in any case good practice to carry out calculations from such comparatively rough data to a hundredth of a second of arc. And one has only to look at Mr. Mitchell's calculation to see that the method, however formally sound, is extremely unsuitable to the particular case of observations close to the pole. The sines of small angles of a few minutes of arc are continually required in the calculation, and not even 7-figure tables to single seconds of arc are any good: their logarithms must be obtained by supplementary calculations not shown in the laborious pages reproduced.

Also there are frequent ambiguities of sign not easy to resolve. And since Mr. Mitchell claims that "the more lengthy but mathematically accurate methods" are preferable to the graphical solution because they give "safe and satisfactory checks on the mechanical operations of the computations as well as on the theory of the problem" we are compelled to suggest that the published calculations hardly support this claim. The values for τ which he deduces from his log tan τ are evidently given the wrong sign: what he really finds is two values of $-\tau$. He selects one without remark, and applies his λ to obtain two values of the local hour angle, again with negative sign unindicated: the first column deals with the second observation, and the second with the first. This interchange, with the unindicated changes of sign, make both the mechanical operations and the theory unnecessarily hard for the simple student of arctic exploration to follow, even when he has successfully negotiated the preceding ambiguities, and has supplied at least four of the symbols ^{n} for the logarithms of negative quantities which Mr. Mitchell has omitted.

To the alternative calculations of Mr. Duvall there are quite different objections, for the whole method is unsound geometrically. From the observed altitudes, and with assumptions for the latitude, he calculates the hour angles of the Sun. It is an elementary principle that in any latitude one does not find the hour angle from the observed altitude unless the Sun is well away from the meridian; and that close to the pole, when if it were not for its motion in declination the sun would be describing very nearly a horizontal circle, it is hopeless to try to find local time at all. The formula which Mr. Duvall uses does not distinguish between hour angles east and west of the meridian. In ordinary cases there is no difficulty: one labels the sight morning or afternoon. But when Peary halted at Camp Jesup he did not know *a priori* whether he had gone beyond the pole or not, or in which hemisphere, eastern or western, he was. Morning or afternoon, noon or midnight, meant practically nothing to him. Within a few miles of the pole, at the beginning of April, the altitude of the Sun at midnight is greater than that at the preceding noon, owing to the rapid

increase in declination. Hence we maintain that Mr. Duvall's calculation has no value except as a check upon the numerical accuracy of Mr. Mitchell's. By his series of approximations to the latitude Mr. Duvall is able to check Mr. Mitchell, for his method is, as he says, very sensitive to small changes in the assumed colatitude. Most of us would say that it is altogether too sensitive. Consider these calculations by his method; the 2nd and 3rd are his, the 3rd recomputed by us; the others ours:

Assd. Lat.	*Hour angle Obs.* 3	*H. A. Obs.* 4	*Difference*
89° 55′ 00″	151° 14′ 25″2	71° 32′ 01″8	79° 42′ 23″
55 22·3	160 01 36	69 59 26	90 02 10
55 22·5	160 08 28·0	69 58 33·8	90 09 54
55 30	165 09 49·0	69 23 42·8	95 46 06
55 35	170 01 44·0	68 59 18·2	101 02 26
56 00	No solution	66 40 42·4	—

A simple consideration shows that for latitude 89° 55′ 40″ there is also no solution for Obs. 3. It comes then to this, that if we assume latitudes round about 89° 55′ 22″ a solution is possible by this method. Assume it only 18″ greater and there is no solution. Yet the observations themselves are not nearly accurate enough to say that 89° 55′ 22″ is a possible and 89° 55′ 40″ an impossible latitude for Camp Jesup. Consequently Mr. Duvall's method is unsound. It will not work if one starts more than 18″ on one side of the eventually concluded latitude. In our review we suggested that he had had the advantage of starting close to Mr. Mitchell's concluded latitude. He assures us that we were wrong, and that he started independently and proceeded by a series of approximations of which the two pages published represent only the final stage. But if it is not permissible to think, as we did, that he started very near the latitude which was eventually deduced, then it is perhaps allowable to say that he was fortunate in not starting 20″ greater. If from a preliminary view of the observations he had remarked that Obs. 3 is inconsistent with a latitude greater than 89° 55′ 40″, he would nevertheless not be entitled to say that that latitude was impossible within the limits of accuracy of the observations: and that can mean only that his method is unsound.

A word on the graphical solution which we produced to illustrate our review: It is not the graphical solution known to all navigators as the Sumner method. That, in its usual form, becomes impracticable near the pole. When one is near enough to the pole to take the position by account as the pole itself, the solution suddenly takes on an engaging simplicity, but it is not "the usual graphical method." It was published by one of us in 1910. It was re-invented in the U.S. Hydrographic Office in 1925 when Admiral Byrd was preparing for his flight to the Pole. In more elaborate forms it, or something like it, has been used in other polar flights. But it is really simple only close to the pole, and so simple then that when one of us was reading Professor Hobbs' book in an armchair before the fire, without any tables or instruments he sketched on half a sheet of paper in ten minutes, estimating the angles, a solution which differed only about 0′.1 from that published. This it was that seemed to make it worth while to enlarge the review on the particular lines it followed; to point out that elaborate trigonometrical solutions, with all their ambiguities, are inferior to a simple graphical solution which is unique. And from that position we are not disposed to recede.

A. R. H.
J. M. W.

REVIEWS

EUROPE

THE LAND OF BRITAIN: The report of the Land Utilisation Survey of Britain. Edited by L. DUDLEY STAMP. Part 1: Ayrshire (pp. 83). By JOHN H. G. LEBON. Part 2: Moray and Nairn (pp. 87–124). By F. H. W. GREEN. Part 53: Rutland (pp. 38). By MARGARET E. BROUGHTON. Part 78: Berkshire (pp. 112). By J. STEPHENSON; with an historical section by W. G. EAST. *London: Published for the Survey by "Geographical Publications,"* 1936–37. 11 × 8½ *inches; maps.* 2*s* 6*d*, 2*s*, 2*s*, 2*s* 6*d*. (*Subscription for whole series, probably* 87 *parts*, £5 0*s* 0*d*)

These four Reports of the Land Utilization Survey of Britain have several features much in common despite the contrasting characteristics and sizes of the areas with which they are concerned—contrasts which largely explain the varying lengths of the Reports. The treatment of the material follows the same general plan and the facts are presented in a straightforward manner. Carefully prepared and selected illustrative matter accompanies the text. These illustrations are vital in this type of publication and many of those included are of a very illuminating character. Each of the Reports is the work of a representative of the younger generation of professional geographers. Due acknowledgment is made to the many voluntary surveyors of the field sheets and in each case publication has been possible through grants from the Pilgrim Trust and donations from private individuals.

It is pleasing to record the distinctly useful character of these Reports. The published map sheets have already become familiar to many. The first map sheet of this type, for a part of the Northants area, was published in 1929, while an early recording of a survey with a comparable objective and as a definite practical exercise was contained in Simmons and Richardson's 'An introduction to practical geography,' in 1908. The development of the present Land Utilization Survey has taken time and has not been without difficulties, and the field work to which the Reports are related frequently extended over a considerable period. The possibilities of re-surveying the areas in connection with the preparation of the Reports considerably reduce the problems of the extended period of working.

The details of present land use are preceded in the four Reports by concise statements concerned with the geographical background, the facts of structure, relief, climate, and soil. In the case of Berkshire the author describes seventeen well-defined relief divisions and even in the smallest historical county, Rutland, a "variation of physical conditions which is remarkably complex" is noted. Climatic data provide something of a problem. For the most part details are unobtainable other than for a limited number of stations, and it may well be that this kind of investigation will help towards an intensification of recording points. The same difficulty experienced by these authors has been encountered in 'An agricultural survey of the Northern Province,' by J. A. Hanley, A. L. Boyd, and W. Williamson, a publication to which reference may be made since it too adds to our detailed knowledge of the present-day agriculture of this country. Soils, like climate, in some instances provide difficulties. In the cases of Ayrshire and Berkshire the authors found much valuable material available; for Moray and Nairn information was only available for parts of the area, while for Rutland the soil conditions have had to be deduced from the geology with amplifications and additions from local knowledge. In the process of stating

the soil conditions indications of the uses to which they are put are given and we are then led on to the several statements of land use with evidence as to the distributional facts of the present time. In the Report on Ayrshire, "pre-eminently a dairying county by force of the facts of the physical geography," these data are preceded by a history of Ayrshire farming. Advantage is taken by this arrangement to outline the changes in land use over the modern period, stress being laid upon such items as changes in animal management and the development of marketing systems and of creameries over the Ayrshire plain as the region has adapted itself to modern dairying practice. In Moray and Nairn the evidence shows that, apart from the high moors, seven-tenths as a rough estimate of the rest of the region is improved land and of this improved land about 86 per cent. is under the plough. The relatively high proportion of woodland is also considered. In Rutland there is the report of the predominance of grassland, especially in the west of the county. Methods of use of grassland are incorporated in the distributions and the almost sheepless character of certain parishes is explained as being due to the influence of hunting interests. The decline in the arable areas of the county over the last thirty years is emphasized. The present arable zone, mainly in the east of the county and associated with the lighter soils, is characterized by a "sheep-barley" farm economy. In the Berkshire report these facts are considered at greater length, systems of rotation and details relating to particular crops being dealt with. Precise reference to the distribution of settlements is made by all four authors.

With these distributional facts of land use, detailed according to the nature and quality of the areas with which the Reports are concerned, the second stage is reached in the divisions of the counties into land-use regions. While such divisions allow useful groupings and correlations of the data and are based upon evidence from the many sources, they will no doubt give rise to discussion. The authors stress the problems which they have encountered in this matter and comments such as "no two workers would agree as to what divisions should be made" and "their exact demarcation is difficult in some cases" are common to all. It will be of interest to note the degree of correlation evident, in terms of land-use regions, when a group of adjoining county areas have been divided by different authors. Until such a position is reached, with its obvious advantages, further comment on this aspect is better withheld, but it may be noted that in each of these particular cases the divisions evolved are numerous, ranging from twenty-five in the case of Berkshire to five in the case of Rutland.

The land-use regions complete the major body of each Report. In two cases, Rutland and Berkshire, sections on past land utilization follow, while in the case of Ayrshire statements are made on animal husbandry and marketing. In every case there are appendices incorporating statistical tables and lists of surveyors of field sheets.

The Reports deserve attention. They contain much useful information and will act as stimulants in several ways. It may be legitimately hoped that they will cause further investigations in such related fields as climate and soils. Finally one must hope that the response to them may encourage the preparation and completion of others so that over the shortest possible time a valuable series of records may be generally available. G. H. J. D.

NORTH COUNTRY. By EDMUND VALE. ("The Face of Britain" series.) *London: B. T. Batsford*, 1937. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* viii + 120 *pages; illustrations and sketch-map.* 7*s* 6*d*

This book in the "Face of Britain" series brings out the dual nature of that part of the country which lies between the Cheviots and a line drawn from the

Mersey to the Humber. It portrays, in the text and in photographs, the industrial north which is largely the product of the so-called Industrial Revolution and the agricultural north which is largely the product of a thousand years of history. Mr. Vale emphasizes the changes which are taking place in both the rural and the urban areas, but he is perhaps least happy when he is most topical: the chapter on slum clearance is scarcely an adequate statement of the case. His dislike of the modernization of village life appears to be based on an idealized view of the past. Cinemas may have taken the place of knitting meetings in the dales, but the latter were but one aspect of what was often sweated labour. Again, is the conversion of a country fair ground into a recreation ground, complete with swimming pool, necessarily "an irreparable blow to gaiety" ?

The photographs, more than 130 of them, are excellent. Even Kilnsey Crag appears from a new angle. Unfortunately both the text and the end maps contain errors. Thus Swaledale is given incorrectly as Swayledale, Burtersett as Bartersett, Widdale as Whiddale, and Bainbridge, though spelt correctly in the text, appears as Bainsbridge on both the maps. Hawes Junction has for some time been re-christened Garsdale by the railway company to which it owes its existence. T. S. W.

ATLAS REPUBLIKY ČESKOSLOVENSKIÉ. Atlas de la République tchècoslovaque publié par l'Académie tchèque sous les auspices du Ministère des Affaires Étrangères de la République tchècoslovaque. *Prague: Éditions Orbis S. A.*, 1937. 18×18 *inches.* (*Issued in* 18 *parts at* 40 *kč each*)

The 'Atlas Republiky Československié,' published at Praha under the general editorship of Dr. Jaroslav Pantofliček, with the assistance of a distinguished band of collaborators, is based throughout upon official sources and offers a firm practical foundation for the study of the geography of Czechoslovakia. The Atlas consists of 442 maps on 54 double sheets measuring 32×75 cm. Of these maps, 78 are directly geographical (topography, hydrography, geology, climate, vegetation, etc.), 122 are demographic, while the remainder deal with the various aspects of economic life: agriculture, manufactures, power and resources. The general maps, occupying a double sheet, are on the scale of 1 : 1,250,000, and the peculiar shape of the country, with its long corridor-like eastward extension, allows of free insertion of relevant insets on the same page. Titles and keys are given in French (or alternatively in English or German) as well as in Czech, while there is an explanatory and supplementary text of 37 pages.

The Atlas produces an immediate impression of satisfaction and pleasure for it reaches an extremely high level both technically and artistically, reflecting the highest credit upon the Military Cartographical Institute which undertook the printing. The outlines and lettering, although perfectly clear, are so finely executed that they never obscure or disfigure the overlying colours, and the colours themselves are so delicate and so exactly in register that at a first glance the Atlas appears to be exquisitely hand-coloured throughout. It is evident that a very careful choice of paper, thick, smooth, and with a matt surface, has contributed to produce these excellent results. Generally speaking, the statistics are mapped by graded tints in relation to administrative areas as units. As these areas are small, a close approximation to the actual distribution is obtained, and correlations can be made without difficulty with topographical, climatic, and other factors. Circles and rectangles of sizes proportional to the figures they represent are also employed, sometimes in combination with flat tints, but the so-called "dot-map" method of representation of distributions has, perhaps wisely, been rejected. Nor are there any novelties: familiar and well-

tried cartographical devices are retained, and the possibilities of misinterpretation reduced to a minimum.

No analysis or interpretation of the facts which the maps reveal can be attempted here. It is sufficient to say that every sheet of the Atlas emphasizes and re-emphasizes the fundamental contrasts between Bohemia and Moravia on the one hand, and Slovakia on the other. Even the incidence of particular diseases, and the causes of death respect the political boundary, reflecting, it must be presumed, the great contrasts in population grouping and in habits of life. But within Bohemia itself there are also astonishing contrasts, astonishing, that is to say, until the complexity and variety of structure, lithology, and soil within the Massif are recalled. Here we have a microcosm of Central Europe, and this magnificent Atlas is worthy of the closest study, not only by the geographer, but by students of social science and politics, who will here find the clues alike to the weakness and the strength of one of the most interesting and vigorous of the post-War Republics. E. G. R. T.

POLISH COUNTRYSIDES. By LOUISE A. BOYD: with a contribution by STANISŁAW GORZUCHOWSKI. *New York: American Geographical Society (Special Publication No. 20)*, 1937. 10×6½ *inches;* xii+236 *pages (including 156 pages of plates); illustrations and maps.* $4.00

The author spent some twelve weeks in Poland at the time of the International Geographical Congress in Warsaw in 1934, and toured parts of the country by car, aided by Drs. Gorzuchowski, Rewieńska, and Winid as interpreters. The body of her book consists of Miss Boyd's presentation of the Polish countryside and its problems by means of a detailed photographic record of her journeys. A visit to Pomerania was followed by a journey to the north-east as far as Wilno, and then by a longer tour from Warsaw to the Carpathians, east to Podolia, and thence through Volhynia and Polesia. The text, though far from dull, is sober and concise: the minimum requisite to explain the plates. There are close on five hundred of these, covering every aspect of country life: people, settlements, transport, and farm methods. They are well reproduced, and some, particularly those of the marshes, are very fine. About one-half of them occur in the text, and the rest are grouped by topics at the end of the book. They are extremely carefully arranged and indexed, both topically and by location.

Dr. Gorzuchowski contributes a brief final chapter on rural Poland: its regions, population, types of settlement, architecture, and markets, illustrated by appropriate maps. It is clear that the backwardness of eastern Poland is probably due rather to the nature of the land than to its having been under the Russian government, as Miss Boyd suggests (p. 5). The best of Poland fell to Prussia at the time of the Partitions. The term *cerkiew* (*cp.* Russian *tsirkof'*), referring to the churches of the Ruthenians in east Poland, is not (p. 39) necessarily derogative: it means specifically an Orthodox church, whereas *kościol* (Latin: *castellum*) is used for a Catholic one. J. P. H. M.

VATNAJÖKULL: Kampen mellem Ild og Is. By NIELS NIELSEN. *København: H. Hagerup*, 1937. 10×7½ *inches;* 124 *pages; illustrations and maps. Kr.*7.75

Increased interest has centred around the Icelandic glacier Vatnajökull ever since the eruption, in March 1934, of the volcano of Grimsvötn situated beneath the ice. Dr. Nielsen now gives us a most interesting study on Europe's largest glacier and on Iceland's volcanic system. The task which he has set himself is "an investigation of the colossal natural catastrophes which take place when the volcanic forces break forth beneath the sheet of inland ice." In Iceland natural catastrophes occur "at a speed and with a violence hardly to be found

in any other part of the Northern Hemisphere," and that corner of Europe is "an unique, large laboratory where the World is seen in the making."

As soon as the author heard that Grimsvötn had broken forth he organized an expedition and was fortunate enough to reach the scene of the outbreak when the eruption was in its last phase. He was thus able to make an investigation while the volcano was still active. Several chapters are entirely devoted to the 1934 expedition, giving details of the equipment of the party, the route followed, and the difficulties encountered. When Dr. Nielsen again visited Vatnajökull, in 1936, one of the principal objects of the expedition was to ascertain whether the places where eruptions had occurred had cooled between two outbreaks. He considers that tests should be carried out at intervals of two to three years between now and the next outbreak.

The author has not yet fully utilized the data obtained in the course of his last two expeditions, but the importance of his researches may be judged from what he has to say about the palagonite formation which has so long puzzled geologists. He had expected to find a new formation resembling the old one and confirming the theory that the greater part thereof was formed during the process of sub-glacial volcanic eruption. Both in 1934 and 1936 his investigations in that direction gave a negative result which, at the time, greatly surprised him, but he now suggests that the origin of the palagonite formation will soon cease to be a mystery: "Noe-Nygaard and I made, independently of each other, after we had come down from the glacier, a lucky discovery which, we think, will lead to the solution of the problem."

The book covers a far wider field than the 1934 and 1936 expeditions to Vatnajökull. It makes a short survey of previous expeditions, beginning with that of W. L. Watts in 1875; it discusses the various types of volcanoes to be found in Iceland; and it treats of many other kindred subjects of interest to geographers and geologists. It is a valuable contribution to the literature on Iceland, and possesses the very great merit of being written in a simple style not overloaded with technical expressions, which makes it pleasant reading for the layman interested in natural phenomena. The photographs are excellent. F. M. M.

ASIA

THE SYRIAN DESERT: Caravans, travel and exploration. By CHRISTINA PHELPS GRANT. *London: A. and C. Black*, 1937. 9½×6 *inches;* xvi+410 *pages; illustrations and maps.* 18*s*

Here is a much-needed work on a region of such ancient historical significance, and of such vital modern importance, that one is surprised at it being left so long without a chronicler. But there is a reason for it. A book on the Syrian Desert written prior to the Great War would have excited as much attention as a book about some Arctic region with no historical background whatsoever and no likely future. Only the re-shaping of Powers in the Near and Middle East, and the new era of petrol and planes have caused the Syrian waste to attain a prominence that it never reached before. Practically the whole of this book, with the exception of the last chapter, could have been written before 1914. But it is the subject-matter of this last chapter which creates the main interest, for it records the post-war period which has recalled the Syrian Desert from oblivion, and re-established it as one of the main lines of communication, and indeed the shortest line, between the East and the West. Dr. Grant has realized that this dead world was coming back to life, and that the region would figure large in future relationship between Europe and Asia.

The region in question is the historic and strategic triangle marked out by

Damascus, Aleppo, Baghdad, and Basra: a desert, or rather an arid steppe, *uniting* adjacent lands, instead of dividing them. "For more than three thousand years the trade-routes of this desert have linked the Eastern seaboard of the Mediterranean with Mesopotamia; they have fostered cultural and religious, as well as commercial exchanges between the Near and the Middle East. Furthermore, until the opening of the Suez Canal, the Syrian Desert was almost universally recognized as a short-cut between Occident and Orient." That is the background to the picture which Dr. Grant paints for us, extending it over eight long chapters. The survey of this historical period is of the greatest possible merit, for it cannot be found elsewhere. It shows the region in its true rôle, as the passing place of many, the abiding place of none. Parthia and Rome, it is true, got as far as any in attempts to settle it, and only during the first and the third centuries A.D. did great frontier stations and caravan cities, such as Dura, Palmyra, and Busra, have their day. It was as a caravan route that it held its own throughout the ages, and it is as the main corridor to the Orient that it holds our interest to-day. The periodic rise and fall in the use of the Syrian Desert, throughout three thousand years, is shown by a graph. The peak was reached in the Graeco-Roman days, when the desert was not the desert it is now, and it has again reached the same high level in post-war days, when presumably oil has neutralized the difficulties imposed by arid conditions. It sank to its lowest ebb during the fourth century B.C., the fourth century A.D., the thirteenth and the fifteenth centuries—periods corresponding with aggression by Macedonian, Persian, Mongol, and Turk.

Dr. Grant has collected the information of centuries—much of it not easy to come by and scattered in many languages—and given it to us in a readable form. There are eighteen pages of selected bibliography, which shows she has not scamped her job; there are also illustrations and maps. Written in a scholarly manner, it is obviously a standard work for many years to come.

After a suggestive chapter on the channels of ancient and mediaeval trade, there follows the story of all travellers and explorers in this region from the early Moslems to almost the last aerial survey. The full history of caravan traffic in all its forms makes good reading, but perhaps to the average Englishman the accounts of those eighteenth-century employees of the East Indian Company, who habitually looked at the Syrian Desert as their short cut home, will most appeal. Great human interest attaches to these sections and they give us some first-hand accounts of the desert crossing. The last chapter on the modern conditions in the Desert, of the development of organized traffic totally independent of local faction and feud, and of Nature's obstacles, is of paramount interest.

One trans-desert journey we should like to have seen included: that remarkable feat of Khalid's, when he was transferred from Iraq to Syria in 633–4. For this forced march with 9000 men, from Ain-at-Tamr, west of Karbala (actually on the Great Desert caravan route) to Palmyra, has caused a lot of discussion. What was Khalid's route? The theory that he went by way of Jauf, thus nearly doubling the distance he had to go, and having to face the impracticable crossing from Jauf to Palmyra seems to me to be fantastic, in view of the comparatively easy direct line of approach followed by Chesney in 1837, Thielmann in 1872, and Bell in 1914—in fact the old fortified caravan route of Zenobia's day. But we should have liked to have known Dr. Grant's mind on this greatest of all *ghazzus* that set forth to cross the Syrian waste.

If there is one criticism to make, it is that Dr. Grant is too restrained. She might have let her imagination run riot on the eternal struggle between the settled and the nomadic worlds, of which this region is the meeting-place.

This is made in no carping spirit, but merely as a suggestion to Dr. Grant that she has the material for another fascinating book on the same subject.

D. C.

MESCHHED: eine Stadt baut am Vaterland Iran. By G. STRATIL-SAUER. *Leipzig: Ernst Staneck*, 1937. $8\frac{1}{2} \times 6$ *inches;* 168 *pages; illustrations and sketch-maps. M.*5.50

Herr Stratil-Sauer has already written several books on Iran, in which he has paid particular attention to its eastern provinces. At the beginning of the book under review he says that it is a sign of optimism to write a work on a distant city in the East. Yet he is surely justified in having chosen Meshed: with its long and by no means uneventful history, it is a worthy theme.

Meshed has a very special position in Iran, although in point of size it ranks no more than third. Much of its importance is due to its being the most holy city and the chief place of pilgrimage, a position which it owes very largely to the strong nationalist spirit of the Safavi Shahs (in particular, Shah 'Abbas I), who did much to embellish the shrine of the Imam Riza in order to attract pilgrims, while they sought to discourage their subjects from going to the Shi'a holy places abroad. Further, Meshed is a place of great strategic importance by reason of its situation close to the Soviet Central Asian and Afghan frontiers.

In his historical outline of the town the author describes how waves of invaders from the north-east have repeatedly swept into Iran through the Meshed district, and how from distant times caravans have passed along the natural trade routes at whose point of intersection the city lies. Its population, like its relative importance, has fluctuated greatly; in Nadir Shah's time, when it was the capital of his extensive but ephemeral empire (a fact on which Herr Stratil-Sauer should have laid some stress), it had over 200,000 inhabitants. Four years ago its population, including the surrounding villages, was estimated as being between 130,000 and 160,000. The author devotes some space to the trades and industries not only of Meshed itself, but also of the district of which it is the centre, and he gives some useful statistical tables. It is still a great religious centre and a place of pilgrimage, but it is nevertheless being modernized. Thanks to the progressive policy of the Shah, several broad new avenues have been cut through the town, squalid areas have been demolished, and new buildings, including a number of schools, which harmonize well with the spirit of the place, have been erected to designs by Iranian architects. No detailed account is given of the shrine of the Imam Riza, which has already been described by Sir Percy Sykes, Colonel C. E. Yate, and Herr Streck. For the future, Herr Stratil-Sauer envisages prosperity for the city, particularly if breaches can be made in the tariff walls surrounding Iran, so that goods may pass freely along the natural trade routes which converge at Meshed.

The bibliography is in two sections, in the first of which are placed the works of those who have actually visited Meshed (the year or years in which they were there is indicated). This bibliography is fairly extensive, but it might with advantage have been somewhat longer. The Sani'u'd-Dauleh's 'Matla'u'sh-Shams,' a really important source, should certainly have been included (it is referred to only in a footnote on p. 74), and Sir John Malcolm's 'History of Persia' is worthy of mention. Further, the gap of just over four centuries between Clavijo and Truilhier might have been somewhat shortened by the inclusion of George Thompson, who visited Meshed in September 1741; his 'Journal' contains some interesting details of the city as it was when it was Nadir Shah's capital. The name of van Mierop, who was there some three years later, might

also have been given; Jonas Hanway, in his 'Travels,' gives extracts from the journals of both Thompson and van Mierop.

The book is illustrated with some good photographs, and there are several sketch-maps. L. L.

METEOROLOGY FOR AIRMEN IN INDIA. Part I. General meteorological features. iv+53 *pages. Rs.* 4/12 *or* 8*s.* Part II. Climatology of air-routes. v+53 *pages. Rs.* 2/2 *or* 4*s* 10*d. Delhi: Manager of Publications (for the India Meteorological Department)*, 1936. $9\frac{1}{2} \times 6\frac{1}{2}$ *inches; illustrations and maps*

This is a publication of great interest to aviators in India, and would be invaluable when planning flights some time ahead. With its large desert areas, high mountain ranges, and monsoons, India probably presents the greatest and most definite contrasts in meteorological conditions of any part of the world, and provides excellent material for the student of meteorology. Part I gives a general description of the weather likely to be experienced in any district at any season of the year under average conditions, and gives an interesting and instructive account of the general meteorological features of the country. Part II gives detailed climatological notes on all the likely air routes over India. With a knowledge of both parts, a pilot could foresee the weather conditions he would be likely to meet on the route he requires, and with this advance information he should be in a position to make full use of the forecasts and current weather reports which can be obtained day by day from the India Meteorological Department. D. F. M.

THE TWENTIETH CENTURY IN THE FAR EAST. By P. H. B. KENT. *London: Edward Arnold & Co.*, 1937. $9 \times 5\frac{1}{2}$ *inches;* 390 *pages; maps.* 16*s*

Mr. P. H. B. Kent, senior member of the English Bar practising in China, with thirty-five years' experience in the Far East, has produced a workable book on China which leads his readers directly to their goal without presupposing too much detailed knowledge on their part. He presents a very fair and commendably lucid picture of twentieth-century affairs in the Far East with sufficient foregoing history to enable an appreciation of the facts which led up to them. After a very brief but none the less vivid account of the Boxer Rebellion (in the non-success of which lie the roots of so much of to-day's development) there follows a chapter on the Anglo-Japanese Alliance which may at this moment be of special significance and is a useful remembrancer of our relations with Japan to-day. The subsequent chapters deal with the chain of events which culminated in Japan's secession from the League of Nations and the world-wide condemnation of her attitude towards her neighbour China. For the traveller, who will need something to compensate him for the lack of surface interest in what are the two principal cities from an economic point of view, there are two chapters on Shanghai and Tientsin. Especially in face of the rapid development of the former it is well to possess a working knowledge of the background of this important centre of commerce. Otherwise, with implicit faith in first-hand impressions, the visitor may find himself embracing the arguments of young China, ignorant of the hard facts which in the past necessitated extraterritorial rights in a country whose methods and point of view were so completely at variance with our own. The sum total of Mr. Kent's book strengthens the impression that from the standpoint of culture, no less than of economic development, it is essential to the mutual interests of China and Great Britain to safeguard and cherish the links of friendship which have weathered so many storms and firmly withstood the test of time. B. M. G.

AFRICA

THE SOUL OF NIGERIA. By ISAAC O. DELANO. *London: T. Werner Laurie*, 1937. 9×5½ *inches; 252 pages; illustrations and map.* 10*s* 6*d*

As an intimate statement concerning the everyday life of a Negro community this book is indispensable to the student of West African social history. To the geographer it is perhaps not of equal importance, though its pages will be read with interest because the author is a native of West Africa. Our knowledge of the people of this region has been, until recently, dependent upon the writings of European visitors who, whatever their opportunity or ability, have generally proved unable to free themselves from the prejudices of an intellectual environment far removed from that of the African; and the time has come to allow the African to speak for himself in the simple and direct manner which is characteristic of him. Isaac Delano is an efficient spokesman: he is, apparently, a Yoruba, and he refers almost exclusively to his own people, especially those of lowly rank. For ten years, he tells us, he travelled throughout Yorubaland, remarking and recording the customs and activities of one of the most gifted communities in West Africa, and he endeavoured more particularly to describe the life of those of his countrymen who are not yet seriously affected by "westernizing influences." As a literary achievement the book merits high praise; the style is simple but fluent, and there is in the *naïveté* of thought and phrase a charm that is absent from more sophisticated writing. The frankness displayed will be somewhat disconcerting to the European, especially to the administrator and the missionary, for the author questions the very foundations of the education and religion which have been introduced from Europe. He asks whether school teaching is intended to produce good Africans, or black models of Europeans. His warning that many of the Christian Yoruba are tired of a religion which is not sufficiently concerned with their everyday problems of life should be taken seriously. In the book there is little attention to the country itself, to its landscape, climate, or other form of natural endowment, and to the geographer this must be the most serious deficiency. W. F.

NORTH AMERICA

POPULATION DISTRIBUTION IN COLONIAL AMERICA. By STELLA H. SUTHERLAND. *New York: Columbia University Press* (*London Agents: Oxford University Press*), 1936. 9×6 *inches;* xxxii+354 *pages; maps.* 20*s*

Many serious difficulties face a writer who wishes to construct maps showing the distribution of population at periods of history before regular censuses were taken. There are no full statistics of the population of the United States of America before the first census of 1790. The author of this work has set out to obtain a picture of the distribution of population in America at the end of the Colonial period, that is in about 1775. By using tax-returns, lists of land grants and similar material, as well as a few censuses for some areas, it has been possible to compile what must be a reasonably accurate statistical account of the distribution of population that existed at that period. Three maps, each on a scale of 24 miles to 1 inch, show the distribution of population; one dot is used to represent fifty persons. The value of these maps is considerably reduced by poor draughtsmanship: the dots are of uneven size and are not clearly reproduced.

It is of the greatest importance to have a statement of the numbers of population in 1775, as the increase between that date and the first census was very rapid. The first federal census of 1790 gives a total population of 3,699,525,

and the estimate for 1775 given by the author is 2,507,180. Of the latter figure, 533,000 were negroes, 200,000 were of German and other alien stock, the rest being of British origin. The author is not content to give us this useful information, but she also attempts to analyze the growth of population in each colony from its beginnings in the seventeenth century. These facts are related to topography and the fertility of the soil. The eight chapters of the book which deal with the development of population contain a great deal of material that will be valued by any student of historical geography. In an appendix the author has compiled various tables which show the commodities imported into American ports in the year 1771–2. Similarly the exports to Great Britian, to Ireland, and to southern Europe from each American port are also listed. There is a bibliography of 16 pages, but there appears to be no mention of F. B. Dexter's paper, published in 1888, on "Estimates of population in the American colonies." Dexter's figures, which differ in some respects from those now given to us, were used by the authors of the recent 'Atlas of the historical geography of the United States.' E. W. G.

AUSTRALASIA AND PACIFIC

NAVEN: A survey of the problems suggested by a composite picture of the culture of a New Guinea tribe. . . . By GREGORY BATESON. *Cambridge: University Press*, 1936. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* xviii+286 *pages; illustrations.* 18*s*

What is the relation between theory and field-work in social anthropology? This is the main problem raised by Mr. Gregory Bateson's study of the *naven* ceremonies which he found among the Iatmul, a people inhabiting the middle reaches of the Sepik River in New Guinea.

Naven ceremonies are performed in order to celebrate the achievements of growing boys and girls, when they have for the first time performed some act which is regarded as specially creditable by the tribe. Such achievements are, in Iatmul culture, a source of pride to various relatives of the young people, in particular their classificatory "mother's brothers," who celebrate in an unusual way, by assuming the clothes of the opposite sex and by caricaturing female behaviour. In *naven* these men dress up in the garb of widows, wearing the special string bindings of pregnant women. They stagger about the village, behaving like filthy and decrepit old hags, and asking for their *laua* (sister's child), to whom they present a fowl, the whole ceremony celebrating the achievement of this *laua*. The female relatives celebrating *naven* also indulge in a form of transvesticism, though of a slightly different kind. They assume the very best of their menfolk's ornaments: their finest feather headdresses and homicidal ornaments. Thus arrayed, they walk proudly around the village, making much noise and giving expression to typically masculine patterns of behaviour—anger, pride, and assertiveness.

Taking this rather bizarre ceremony as his starting-point, Mr. Bateson proceeds to analyze it in its relation to the social structure as a whole, to the kinship link between mother's brother and sister's child, and to the ethos of the two sexes in Iatmul culture. By ethos he means a standardized set of emotional values expressed in culturally defined ways of behaving. This is his most valuable contribution, for the author shows that transvesticism in *naven* is not merely a quaint, incomprehensible cultural oddity, but that it serves a useful purpose in social life, particularly by allowing each sex to express an ethos normally alien to it and proper to the other. He argues that Iatmul women adopt the spectacular ornaments of men when they are called upon to express in ceremonial the noisy and ostentatious ethos more appropriate to the opposite

sex. In a similar way the Iatmul men are not accustomed to expressing vicarious personal emotion or pride in the achievements of another person, as they must do for their *lauas* in *naven*. Such an expression is more appropriate to women, so the men dress up in female attire. But why should they choose the filthy clothes of a decrepit hag, while the women assume the best and finest of masculine ornaments? Because, says Mr. Bateson, the women have no contempt for the ethos of the men, whereas the men despise that of the women. In assuming female attire therefore they contrive in the very act of adopting feminine ethos to express their contempt for it by turning the whole performance into a derogatory caricature. However we may disagree with the details of this analysis, we must recognize its importance in stressing the relation between the kinds of activities which are socially prescribed and the clothes which are regarded as appropriate to them. Apparel proclaims not only the man, but also the meaning of his behaviour in its social setting.

Mr. Bateson however is not so much interested in the Iatmul or their *naven* ceremonies as in the formulation of a theoretical system of anthropology. He makes no exaggerated claims for his field-work, which is used mainly to illustrate his arguments. It is impossible to criticize his methodological approach in detail. In general it suffers from an excess of classification, analysis, generalization, and formulation of principles with an almost complete disregard for their vital counterparts: observation, synthesis, verification, and documentation. The main defect of Mr. Bateson's theoretical approach is not that it is new, but that it is detached from the empirically verified body of systematic knowledge which we possess; not that he suggests new methods, but that he ignores what is of value in existing ones. For example, in considering orthodox functionalism, Mr. Bateson gives a useful and stimulating analysis of the meanings covered by the word "function." But here as elsewhere in the book, analysis stultifies synthesis, for he finds the issue "confused" by the use of the term "function" firstly in relation to the satisfaction of human needs and secondly with reference to the inter-dependence of elements of culture, which is in itself a false antithesis. The value of the author's theoretical scheme is not to be assessed in terms of the brilliance with which he has evolved it from his inner consciousness, but by an appeal to empirically observed facts. The ultimate test of any anthropological theory is the quality of the field-work it produces, and Mr. Bateson promises to put his hypotheses to this test in the future. Perhaps a more objective, concrete, and synthetic approach, carried out with Mr. Bateson's undoubted critical ability, will lead to conclusions more definite and therefore more valuable than those suggested in the present volume.

R. P.

PHYSICAL AND BIOLOGICAL GEOGRAPHY

THE QUATERNARY ICE AGE. By W. B. Wright. *London: Macmillan and Co.*, 1937 (Second Edition). 9×5½ *inches;* xxvi+478 *pages; illustrations and maps.* 25*s*

The first edition of this work was published in 1914 and despite the handicaps of the ensuing years it established itself as an indispensable book. Different in method from Geikie's 'Great Ice Age' and wider in scope, it afforded the only up-to-date account in English of much important work on Pleistocene geology. Further, it was far from being a mere compilation. It was written in an easy and lucid style, its pages bore the stamp of personality, and the whole was refreshed by the author's original suggestions at many places. It was a book which could be read and enjoyed, and not merely referred to.

The intervening years have witnessed further extensive work in all aspects

of glaciology and Pleistocene geology. In both editions of the book Gilbert's famous statement will be found quoted: "When the work of the geologist is finished and his final comprehensive report written, the longest and most important chapter will be upon the latest and shortest of the geologic periods." The recent progress of research bids fair to justify this dictum. Accordingly, it was a task of no little difficulty to bring this work up to date, and the reader familiar with the old edition, opens the new volume with some anxiety. The revision however has been done with admirable judgment and we have a definitely improved edition, which is something at once both more and less than the eclectic "botched up" version, replete with footnotes, qualifications, and retractions, so often produced by a hard-driven author pressed for a second edition.

The book has been printed in smaller type and on lighter paper so that, while it contains a dozen extra pages, its bulk is reduced. The general arrangement of chapters stands with only minor modification, but footnote references have been omitted, and collected in bibliographies, following the chapters. These, while not exhaustive, have been brought up to date in respect of leading contributions and even where the text is but little modified, the reader's attention is thus drawn to later work.

New features are as follows: A short chapter on phenomena of retreat includes an account of Kendall's work on glacial drainage channels and of the researches on retreat stages in Scandinavia. Two new chapters deal respectively with the Older Drift and the Newer Drift in the British Isles. The distinction thus fully recognized could only be tentatively indicated twenty-three years ago, and these chapters give the measure of the considerable stratigraphical advances made in the study of the British Drifts. A further short chapter records progress in interpretation of the river-gravels of Southern England, notably those of the Thames, the Cam, and the Avon. New sections in other chapters deal with the Norwegian "strandflat" and possible British equivalents, and later work on the German, Scandinavian, and American drifts, including the European loess. In these accounts considerably greater emphasis is now laid on the evidence of interglacial episodes. This reflects a major change in British opinion on the question. Formerly James Geikie, almost alone, insistently voiced the case for the polyglacial view and perhaps he strained it by overstatement. Opinion has swung full circle however, though Dr. Wright still wisely refrains from an orgy of inter-regional correlation, remarking that correlation-tables often yield an apparently satisfactory result only by ignoring difficulties and that, in general, they inevitably suggest more than can possibly be proved at present.

The former edition contained a brilliant and original explanatory treatment of the oscillations of shore-lines during Quaternary times. It involved interaction between isostatic movements of the crust and what are now called "eustatic" movements of sea-level. This theory stands confirmed and consolidated in large measure and Dr. Wright now terms it the Isokinetic Theory "from the fact that shorelines are cut when the two motions are equal and in the same sense."

Viewing the new work as a whole, the reader's feeling must be one of gratitude that the author has been able and willing to conserve so much of his original matter and treatment. The book can still be read and enjoyed. Omissions there are bound to be and each reader will have his own ideas as to what might be fitly excluded or expanded. Geomorphologists would have welcomed a more particular account of the forms assumed by eskers and kindred accumulations, and of the significance of nivation. Climatologists might not unreasonably claim that the so-called "Astronomical Theory" does not now deserve extended

treatment at the expense of other and later theories. Little is said of the more recent work on the geographical factors conducing to glaciation. But these are matters of opinion; the book represents a major piece of work carried out with good judgment and moderation of outlook, and it will be read with great pleasure by geologists, geographers, and archaeologists. As compared with another recent work of importance, Daly's 'Changing world of the Ice Age,' it well represents the pragmatic British attitude in which the facts are valued more highly than the wider ramifications of theory. But the two points of view are complementary, not opposed. S. W. W.

WEATHER ELEMENTS: A text-book in elementary meteorology. By THOMAS A. BLAIR. *New York: Prentice-Hall*, 1937. 9×6 *inches;* xvi+402 *pages; illustrations and maps.* $5.00

This book, which bears the sub-title 'A text-book in elementary meteorology,' was written with the aim of "presenting concisely and systematically an introduction to the science of meteorology in its present stage of development," and incidentally of "presenting that general body of information about the weather which it is believed that every intelligent person should possess." The result is a book of four hundred pages, copiously illustrated by maps, charts, diagrams, and photographs, of which the smaller charts represent American conditions.

As might be expected of an avowed text-book, the subject-matter covers most aspects of meteorology. Beginning with instruments and methods of observation, the author proceeds to explain some of the physical processes in the atmosphere, giving an account of the functions of water-vapour, not only from the point of view of its possible condensation as cloud and rain, but also from that of its reaction to radiation from the sun and the earth. This leads naturally to the discussion of the general circulation of the atmosphere and of the so-called secondary circulation, followed by chapters on weather forecasting, world weather, and the climates of the earth. A chapter is devoted to climate and man, another to electrical and optical phenomena, and a final one describes the United States Weather Bureau. Appendices give a bibliography of books and original papers on the subject, a set of conversion factors and tables, a set of tables of monthly and annual mean temperatures and rainfall for a selection of stations distributed over the world, and a table of the climatological stations of the United States Weather Bureau.

It will thus be seen that the author has covered a very wide field. He has drawn upon a wide knowledge of the subject to make a text-book which represents the present state of our knowledge of meteorology with reasonable thoroughness. The book aims at giving accepted ideas in a simple form, rather than at putting forward new ideas, although some of these accepted ideas are by no means as well based as one might be tempted to think. For example, the standard explanation of the land and sea breezes, while it appears physically very plausible, is not always borne out by detailed examination of upper air observations, the supposed reversal of the direction of the breeze at no great height not being always present.

The discussion of the ideas underlying day-to-day forecasting is sufficiently full for the average reader. There is however an error in the diagram representing the Bjerknes scheme of the development of a depression, Fig. 67 *d* showing what is now known as a secluded, not an occluded, depression. This is the diagram which was put forward by the Norwegian school of meteorologists in the earliest stage of the development of their theory, and was later replaced by another which represents the depression as being occluded outward

from the centre, in accordance with experience of synoptic charts, at least in Europe.

The reaction of "every intelligent person" to the book is not easy to predict. It is a substantial volume, which is not to be read without care and concentration, and it contains much detailed information which the lay reader will not want to acquire. The present reviewer can sympathize with the difficulty which faced the author in his effort to produce a book for the serious and for the general reader, but he believes that the two aims cannot be reconciled. To the student of geography or any other serious reader who desires to understand the physical principles underlying the weather and climates of the earth the book can be recommended as a sound work. It covers a wider field than any similar book in English with which the reviewer is familiar. D. B.

ON THE MECHANISM OF THE GEOLOGICAL UNDULATION phenomena in general and of folding in particular and their application to the problem of the "Roots of Mountains" theory. By S. W. Tromp. *Leiden: A. W. Sijthoff*, 1937. $9\frac{1}{2}\times6\frac{1}{2}$ *inches;* 184 *pages; illustrations and maps. fl.*6.90

In the first part of this book the author attempts a classification of all wave-like structures, on any scale, that fall within the subject-matter of geology—that is to say, mainly but not exclusively rock-structures. He has brought together in very condensed form the greater number of recent contributions to their study—observational, experimental, and mathematical. The arrangement of the text is not as clear as so complex a collection needs. For instance it would improve the exposition if the preliminary classification on pp. 4–8 contained page references to the fuller treatment of the several subdivisions. Anyone who sets himself to compile such references will soon find the lay-out of the chapter rather confusing: he is sometimes taken from one major division to another with less typographic warning than is given between many minor subdivisions. Provided the reader is prepared for these difficulties he will find the chapter a useful work of reference.

In the two subsequent chapters, the author criticizes unfavourably both the "roots of mountains" theory, originated by Sir G. Airy and elaborated by Osmond Fisher and later by Meinesz and others, and several theories proposed to account for gravity anomalies. Finally he gives a bibliography of some 273 works, a very necessary completion of a book so greatly condensed. While it appears fairly complete in general, the section on glacial folds contains no reference to the important papers by Dr. G. Slater.

The book, in spite of these imperfections, should be a useful guide to the divergent views on rock-folding and orogenesis. It is very clearly printed and the only serious misprint noticed is on p. 105, line 28, where "geosynclines" should read "geanticlines." A. M. D.

CARTOGRAPHY

REPORT OF THE AIR SURVEY COMMITTEE. No. 2—1935. The War Office. *London: H.M.S.O.*, 1936. $9\frac{1}{2}\times6$ *inches;* 184 *pages; illustrations and map.* 4*s*

The Air Survey Committee, formed in 1920, is a standing official committee for the co-ordination of government research in photographic methods of surveying. Its members are derived from the Services, the Ordnance Survey, and the National Physical Laboratory; its first report was issued in 1923, the present one, after an interval of twelve years, being the second to be compiled.

The earlier report was largely concerned with the problems of plotting from single photographs: since then interest has shifted to strips of photographs taken from gyro-stabilized aeroplanes. Much of this period has been spent in developing the well-known "Arundel" method of plotting graphically from sequences of photographs; in addition work has been done experimenting with a plotting machine, the so-called "Big Bertha" described in *Geogr. J.* 76 (1930) 68–70, but since relegated to the Science Museum. A period is now at an end; the present report summarizes progress, compares the situation at home with that abroad, and forecasts the future.

Though dated 1935, the report seems to have been delayed in publication; it was published late in 1936, but it appears to have been prepared in 1934, at which time Captain Thompson's plotter had only reached the model stage and neither the extra-wide angle lens nor the projection plotter known as the "Multiplex" had appeared as new developments abroad.

The composition of the committee being military—there is no commercial or academic representation—the problems taken up have been almost entirely of a military character. Although the report in its first chapter urges the prosecution of proper surveys and points out that the Dominions will at some time have to prepare accurate contoured maps, it is nevertheless clear that it is no aim of the committee to approach the problems of the peaceful mapping of the Empire. "The principal opening for air surveys in the British Empire," states the report, "seems to lie in the direction of cheap small-scale mapping of a reconnaissance type, based on a very sparse ground control, and it is obvious that this requirement cannot be entirely reconciled with the needs of the Services." This is an admission that the military and civil problems are different. It is of course the privilege of the committee to decide its own scope of work; nevertheless, considering the present magnitude of the issues involved, it seems surprising that neither the problem of small-scale mapping, nor that of cadastral survey from the air, should have been mentioned. At this moment the Ministry responsible for the Ordnance Survey is faced with having to develop a new technique for its own large-scale surveys; it is hard to think to what body it can turn for advice if not to this committee.

"Civil developments," states the report in another place, "which are necessarily controlled by economic factors, are not likely to produce a satisfactory solution of military cartographic problems." This turning aside from the civil problems, in which economic factors certainly provide a salutary discipline, has left the private companies without any technical assistance from the only body which, in the absence of any institutional teaching in air-survey, might have been expected to give some advice. It seems a natural consequence that "the cartographic technique employed on the majority of these contracts has been of the simplest kind. This work has on the whole proved to be of little value to the committee. . . ."

One of the most interesting chapters of this report is that describing the present position in photography. Much information about flying for photography and the camera types available is here assembled for the first time. Chapter V (Cartography) on the other hand contains little that is new in the way of theoretical matter; in the description of instruments of foreign manufacture, and especially in the case of plotting machinery, a critical attitude is maintained which seems strange in a country in which none of these machines is manufactured and in an Empire in which none are employed. The judgments are based on theoretical considerations which, in the face of the great volume of work actually carried out by plotting machinery, appear to have more weight on paper than in practice. These arguments seem unfortunately to have played

a part in preventing British instrument makers from sharing some of the present international demand for plotting machinery.

In turning to Chapter VII (The future work of the Committee) we find a statement of the position reached through giving up work on plotting machinery in favour of developing the "Arundel" method. Heights cannot be obtained by the last-named method without dense ground control, and it is difficult to see how any development of technique can overcome this fundamental weakness. The suggestion that aneroid traverses should be made on the ground seems to be as unsuitable for military as it would be for civil purposes.

An appendix describes Captain Crone's ingenious and useful construction for dealing with oblique air-photographs. Another important statement relegated to an appendix runs: "The formation of a suitable air-survey organization on a commercial basis (and this is by no means a new suggestion), combined with a co-ordinated policy of Empire survey, would without question reduce the aggregate cost of survey operations, shorten the time required for their completion and hence open up new areas of undeveloped country much sooner than could possibly be achieved with present-day methods, to the ultimate benefit of the combined wealth of the British Empire." M. A. S.

RAPPORT SUR LES TRAVAUX EXÉCUTÉS DU 1er AOÛT 1914 AU 31 décembre 1919. Historique du Service Géographique de l'Armée [française] pendant la Guerre. *Paris: Imprimerie du Service Géographique de l'Armée*, 1936. 10×6½ *inches;* xxii+352 *pages; illustrations and maps*

This book gives a comprehensive and well-proportioned survey of the work of the French Geographical Section during the Great War. It is remarkable for its detail and for the care which has been taken to include particulars of the many activities which came under the control of the Section. As with the British Army, the change from open fighting to trench warfare demanded a rapid expansion and development of the service to meet the need for large numbers and frequent revisions of large-scale trench maps. Details are given of the steps taken to meet this need, of the organization and functions of the Corps and Divisional Topographical Sections, of the formation of Sound Ranging and Flash Spotting Sections, and of the arrangements for co-operation with the artillery.

The section upon maps describes the materials used in the compilation of the *plans directeurs*, the evolution of the various types and the forms in use at the end of hostilities. The record value of this section of the work is considerably enhanced by the inclusion of a well-chosen series of specimen portions of sheets.

To all who have knowledge of the work of the Geographical Section of the British Army this book will be of great interest, especially as it shows how closely the Geographical Sections of the two Armies developed along similar lines. High tribute is paid to the work of General Bourgeois who remained in charge of the Section throughout the whole period of the war. E. E. F.

ECONOMIC AND HISTORICAL GEOGRAPHY

INTRODUCTORY ECONOMIC GEOGRAPHY. By Lester E. Klimm, Otis P. Starkey, Norman F. Hall. *New York: Harcourt, Brace and Co.*, 1937. 11½×8½ *inches;* viii+492 *pages; illustrations and maps.* $4.00

American school text-books of geography differ fundamentally from those used in this country in the almost invariable adoption of a quarto format. Teachers here consider size and weight of books important in view of the

frequent journeys which the books make in connection with home work. American publishers are not hampered in this way and in the book under review the large quarto format has been extended to use in a text-book of commercial geography for colleges or the first year of a university course. In content this introductory economic geography agrees closely with courses usually followed in Britain. The first part is a brief introduction, part two deals with the physical environment, part three with commodities, part four with commerce and manufactures, and part five gives a regional treatment of the world. In the last part there is, as might be expected, the usual full treatment of the United States with distribution maps from the U.S. Department of Agriculture, but the treatment of Europe is very slight—a page to France and a page shared by Norway, Sweden, Denmark, and Czechoslovakia. But the authors have wide interests and have introduced general principles and specific examples throughout in such a way as to make the book among the best of its kind. It is interesting to note that in world regions the authors follow the recent scheme of Trewartha, which itself closely resembles the original scheme of Herbertson and departs widely from the mathematically precise but untenable Köppen scheme which has so long dominated American text-books. L. D. S.

ḤUDŪD AL-'ĀLAM: 'THE REGIONS OF THE WORLD.' A Persian geography, 372 A.H.—982 A.D. Translated and explained by V. MINORSKY; with the preface by [the late] V. V. BARTHOLD, translated from the Russian. *London: Luzac & Co., for the Trustees of the "E. J. W. Gibb Memorial" (New Series, XI)*, 1937. 10×6 *inches;* xx+524 *pages; maps.* [25*s*]

The anonymous Persian compendium of geography called 'The regions of the world' was discovered, in an unique old manuscript, by the Russian scholar Toumansky as long ago as 1892, but it was not until 1930 that Barthold published a facsimile at Leningrad, with a learned preface which Dr. Minorsky has translated and included in the present book. Barthold himself gave up the idea of translating the work, writing "A great number of geographical names of which the reading remains unknown is the principal reason that has made me renounce the attempt to give a full translation of the MS."

In spite of the Herculean labour involved, Dr. Minorsky has undertaken to translate the very difficult text; difficult, because it rests on a single manuscript not always very clearly written and lacking many diacritical points, so that in numerous passages identification must remain highly problematic, and in many more instances has been established solely by virtue of deep scholarship and encyclopaedic reading. But the translation is only a small part of the book: the translator provides in addition a commentary on his text which, being fully documented and providing the most complete bibliography of each subject touched upon which has hitherto been assembled, gives to the whole work the character of a *magnum opus* on Islamic geography. To enumerate the various items represented—the seas and gulfs, the islands, the mountains, the rivers, the deserts, China, India, Tibet, the Turkish tribes, Khurāsān, Transoxiana, and so westwards to Arabia, Byzantium, and the Khazar—is to indicate the scope of the book.

Much work has been done in recent years towards elucidating the story of Arabian geography, and much yet remains to be done. The treasures of Persia and Turkey are now only for the first time being fully explored, and the discovery of the now famous Meshed unicum of Ibn-al-Faqīh's original geographical work, which is being published at Bonn, gives reason to hope that much interesting material will yet be brought to light. It may be of interest in this connection to mention a zoological work, 'The temperaments of animals,'

written at the beginning of the 6/12th century, of which a fine old manuscript, hitherto unpublished, is preserved in the India Office Library: this work contains chapters on ethnology, and it is remarkable that in the section on Tibet it confirms a conjectural reading mentioned on p. 257 of Dr. Minorsky's book, **Akhā-yul* [for *Ahā-yul*]. On the same page the name *Rāng-rang* occurs: in the India Office MS. this name is written *Ang-rang*.

The Oxford University Press, which has printed the book, has worked with its customary elegance and precision. Detailed indexes complete a work which is a major contribution to human knowledge. A. J. A.

THE EARLIER LETTERS OF GERTRUDE BELL. Collected and edited by ELSA RICHMOND. *London: Ernest Benn*, 1937. 9½×6 *inches;* x+348 *pages; illustrations.* 15*s*

When in 1927 'The letters of Gertrude Bell' were edited in two volumes by her step-mother, Lady Bell, they served almost as an autobiography from the age of twenty-four to the time of her death, but included only some thirty letters written before that age. Since then numerous early letters have come to light, and these are now edited by her step-sister, Lady Richmond, who adds valuable commentaries. Written between the ages of eight and twenty-four they give a vivid picture of her early life and show the gradual development of one of the most remarkable women of the age. Most clearly revealed are a deep affection and sympathy, great enthusiasm, love of adventure and of nature, a remarkable power of observation and ability for describing what is seen and remembered, a capacity for forming her own opinion rapidly and independently, and a gift for making life-long friendships. When reading the letters written between the ages of fourteen and sixteen one is particularly struck by the variety of interests which fill the pages. Politics and politicians even at that age always interested, and modern history appealed more than ancient. Art, architecture, and house-decorating are all stimulating subjects. Likes and dislikes are freely given as when she writes "How I do loathe St. Paul's," going on to give clear reasons for her dislike and showing a grasp of architecture to be noted again a few years later in her descriptions of Bucharest churches. Enthusiasms in spite of adverse criticism were the more remarkable, considering the limitations imposed on a woman at that time. Singing, music, tennis, climbing, flowers, clothes, and innumerable other topics fill the pages as well as descriptions of Oxford days, for at the age of eighteen her dream came true and from Queen's College, Harley Street, she went to Lady Margaret Hall. She had yearned to read history, "to know one thing in the world well at least." There her successful and happy career ended in 1888, and her capacity for making friends, which had been so conspicuous, continued to win her many more in London, as later in various parts of the world.

Travelling, which was to become one of the greatest interests of her life, began when she was eighteen with a trip to Germany. Later come descriptions of a visit to Bucharest and to Constantinople. Back in England lessons in Persian are started preparatory to the journey to Persia in 1892. How charming are these Persian pictures: descriptions of scenery, bazaars, gardens, hawking after quail, moving to Gulahek (the Legation summer quarter), calls on Persian ladies, climbing over the tops of precipices, riding at six before the heat of the day, washing her hair with "delicious mud from Shiraz specially prepared with rose water," hating long luncheons, delighting in Heine's prose, stealing out of the house to sleep in a hammock till the dawn comes. Every page reveals the joy of life and love for those at home, who were to read the pages. Persia brought joy, which ended in sorrow, for there Gertrude Bell met

Henry Cadogan, to whom she became engaged but who died soon after her return to England.

In Persia she learnt for the first time how sympathetic to her were Oriental people, with whom she was to spend the greater part of her life. Yet however great became her love for those distant lands, however great her understanding of Eastern peoples, love for those at home remained the same. On her return to England in 1892 she wrote to her father "What it is to be back and have my mother again! I don't feel really to want anybody but her except you." Such are the last words of the last letter and one closes the book feeling that one has been privileged to watch a remarkable child grow to womanhood and from her own words learn the gradual growth of knowledge and character. E. W. N.

GENERAL

COMPTES RENDUS DU CONGRÈS INTERNATIONAL DE GÉOgraphie. *Varsovie*, 1934. Tome deuxième. Travaux de la Section II. *Varsovie: Kasa Im. Mianowskiego*, 1936. 10 × 6½ *inches; 700 pages; maps and diagrams*

This volume contains the mixture of physical geography that one associates with international congresses, in which the papers include regional treatises that might be published in their respective countries, and a few of more general application that may be over generalized. There is a tendency for international reports to be used simply as media for publishing material that may have but limited international value, and it is difficult to ascertain whether generalizations by authorities carry the agreement of the lesser known authors whose works are thus summarized. Moreover these reports are often unobtainable in libraries, or the series may be incomplete; their presence on the shelves depends on the library subscribing regularly to the congresses or on gifts from persons who attend and receive the literature. Rarely does the library receive more than the *comptes rendus*, while the most valuable information may be in brochures issued at the congress. Many important papers appear in volumes such as this which after a few years are difficult to obtain for reference. To the reviewer it seems that the whole policy of international congress reports needs to be overhauled. Much of the regional and national material could be replaced by good abstracts with suitable references to the full publications elsewhere. The generalizations of authorities, on the other hand, might be given rather more fully but carry generous bibliographical references: sweeping statements that lack chapter and verse to support them may or may not be mere expressions of opinion.

The present impressive volume of 700 pages and very numerous illustrations represents more than a week's almost continuous talking in Warsaw, months of previous work by the authors, and more than two years' hard work after the event by M. Pawlowski and his friends, contending with several languages. The division of labour seems to be unreasonable unless the papers are of international value. It would be difficult and perhaps unfair to enumerate the contents and merits of the contributions that make up the volume. One hopes to find in these reports of congresses a considerable proportion of space allotted to information on the countries in which they are held: there are some outstanding and valuable papers on the physical geography of Poland, but a good deal more was provided in other publications of the congress (e.g. scientific guide books) which is lost to the *comptes rendus*.

The volume is arranged under (A) *Questions:* (1) results of geographical research on the Quaternary; (2) morphology of arctic regions; (3) classification

of climates; (4) morphological studies of coasts; (5) classification of rivers according to their rate of flow. (B) *Reports of Commissions:* (6) for the study of surfaces of erosion; (7) on Pliocene and Pleistocene terraces; (8) on variations of climate especially in historic times; (9) on vegetable and animal population of mountains. The Tertiary and Quaternary studies, general and applied to rivers and coasts, largely predominate and among the contributors one recognizes a considerable number of professional geologists; climate and allied subjects fare badly, not only in volume of material (a poor guide) but in numbers of contributors. While some countries have provided an abundance of material for this volume, others, including our own, are scantily represented. Here again the reviewer thinks that matters of policy of scientific international bodies might be reconsidered.

In this publication the text is clear, most of the figures and especially the maps are well produced, and much credit is due to the Polish committee and to those concerned with its production. There is much important information in this volume: will it receive the attention it deserves? K. S. S.

THE CRUISE OF THE *QUARTETTE*. By W. E. SINCLAIR. *London: Edward Arnold & Co.*, 1937. 9×5½ *inches;* 288 *pages; illustrations and route-map.* 12*s* 6*d*

This is not the first book by this author that has delighted the amateur yachtsman, who, if unable to adventure far himself, likes to spend his winter evenings in the company of sailors more fortunate; and it may be added that Mr. Sinclair has gifts as a writer. He and the mate are experienced deep-water seamen and we do not expect to hear of any hairbreadth escapes or grave disasters; we read with almost monotonous repetition how they made their landfall with the precision of an ocean liner.

Quartette was a trawler built near Brixham; she had plenty of room of all kinds except head-room, and the voyage was undertaken without all the refinements in rig and gear that experience has proved valuable in ocean racing and cruising. Chapter II, on seamanship, contains a number of useful hints and is worth close study.

The cruise began from Falmouth and took them to the Canary Islands, to Porte Grande and Freetown. Here they had their first experience of an all-black town, and the comments of the writer are not complimentary. They next brought up in the little bay of Santa Isabel on the north of Fernando Po. From Sao Thomé they sailed to Ascension Island, and then spent twenty days on the passage to Rio Janeiro. From Rio they sailed for Georgetown, British Guiana: head winds and adverse currents made them log well over 3000 miles, although the distance direct by water is only 2500 miles. The cruise ends at Trinidad. The breezy and critical style of the book and the descriptions of the people and the tropical bazaars make a very readable narrative. H. M. E.

THE MONTHLY RECORD

THE BRITISH FISHING INDUSTRY

For the Buckland Lectures, 1936, Mr. E. Ford took as his subject 'The Nation's sea-fish supply' (Edward Arnold, 1937, price 3*s* 6*d*). The theme is of present importance in view of the Act of Parliament of July 1933, which closed the period of unrestricted freedom for British fishermen on the high seas. The passing of the Act was due in part to world economic conditions, but also to competition from other sources of supply and other foodstuffs. The Act prohibited the landing of fish during the summer months from the far northern grounds, *e.g.* the Murmansk coast and the White Sea, standardized the size of mesh, and imposed size limits on fish to be marketed. The principle was to counteract the earlier practice of "killing first and selecting afterwards." On the Aberdeen haddock grounds, for example, it has been calculated that between 1924 and 1930, 51 per cent. by number of the catch was thrown back. Examples are also given of the destruction of small edible fish in the working of the shrimp fisheries of Germany and Belgium. The question obviously requires international co-operation, and progress in this direction was made by the Convention signed by nine governments in March 1937, based largely upon the British regulations. In his second lecture Mr. Ford deals with the problem of the mesh, and shows that in practice small fish pass through the meshes while the trawl is being towed, and that no loss of earning power results from the use of a larger mesh. His third chapter examines briefly the question of the intensity of fishing and the replenishment of stocks. Halibut has disappeared from the North Sea, through the continual destruction of young fish; the bulk of plaice taken from the North Sea has not declined, but includes a much larger proportion of small fish.

STORM BEACHES OF SOUTH-WEST SCOTLAND

The *Geological Magazine* for March 1937 contains an article by M. S. Ting entitled "Storm waves and shore-forms of South-Western Scotland." The writer maintains that storm waves alone are responsible for the shore-forms constructed at high levels. The storm waves which approach a shore are deflected upslope or thrown up against the cliffs and so are able to build shore-forms above high-water mark. There is of course plenty of direct evidence for the lifting power of waves. Sir Archibald Geikie referred to the breaking of the windows of the Dunnet Head Lighthouse by stones swept with storm surf to a height of 300 feet. The islands of Islay, Jura, Colonsay, and Oronsay are exposed to the west and south-west and afford interesting examples of storm-wave deposits. In Jura all the shingle areas, except those on the shores of Loch Tarbert, face west or south-west towards the dominant and prevailing waves. Loch Tarbert however is a sheltered inlet and the shingled beach is due to the fact that the waves have had to force their way into the rapidly narrowing passage. Here their speed would be increased and they would develop sufficient power to throw materials up to high levels. Special reference is made to deposits illustrated by drawings on the south shore of Loch Tarbert. The highest shingle patch is here a terrace rising only to 30 feet above sea-level, while the lower shingle consists of two sweeping beach ridges. These deposits, which have blocked up a river to form a lake, have been mistaken for raised beaches, but actually they rest on a pre-existing platform backed by a cliff. In places the shingle is seen marking the face of the cliff, and was evidently laid down after its formation.

There are other features which confirm the storm origin of these deposits. Thus the shingle ridges are steeper at the rear slopes. Ordinary beach deposits, on the contrary, do not usually assume ridge form, and in any case do not have steeper rear slopes since they are not thrown up, but rolled up, by the waves. The Jura shingle, again, is only partially rounded, whereas ordinary beach shingle is well rounded. It is further to be noted that the platform on which the shingle rests shows no signs of a marine origin.

To the west of Jura, on the islands of Colonsay and Oronsay storm beaches and ridges are less frequent than sand-dunes. The central part of Oronsay is thickly covered with sand-dunes, and on the southern part of the island grass-covered shingle areas are seen below a thin layer of blown sand. Shingle patches of irregular shape, occasionally mistaken for raised beaches, are very abundant. They have been brought up by storm waves and dropped on the ground above the reach of high water.

The writer goes on to discuss bars, spits, and tombolos along the more sheltered shores of the Firth of Clyde where storm shingle is scarce. These are under-water forms for the production of which storm waves are not necessary. It is not implied that there is any difference between storm waves and ordinary waves except in degree.

REGIONAL NAMES IN CZECHOSLOVAKIA

Some years ago the Czechoslovak National Research Council appointed a committee under the chairmanship of Professor B. Horák to revise the orographical and hydrographical names of Czechoslovakia. The committee examined the orographical names previously in use, defined the areas to which they should be applied, and proposed new names where required. The work was begun by marking on the sheets of the 1 : 200,000 map the limits of the mountainous areas, that is, the lines of marked break in the topography. In this way, the lowlands were also determined; if of sufficiently large area, these were further sub-divided according to their hydrographical relations. Dr. J. Hromádka dealt with Slovakia and Ruthenia, Professor F. Koláček with Moravia and Silesia, and Dr. V. J. Novák with Bohemia. Their proposals were, after discussion, finally approved by the committee and the Military Geographical Institute, which had cordially co-operated in the work throughout. The boundaries thus determined, with the approved names of the areas, were then overprinted in red on the 1 : 200,000 sheets.

We are indebted to Colonel Čermák, of the Military Geographical Institute, Praha, for the presentation of a complete set of these sheets. He and his fellow members are naturally anxious that these decisions should obtain wide currency among foreign geographers.

It is not possible to give here a complete list of these names, but the main results of a preliminary examination may be of interest. The general principles upon which the orographical units have been delimited have been explained above. The larger mountainous areas have been sub-divided by river valleys or other morphological features. The proposed names consist usually of a topographical adjective and a descriptive term, *e.g.* Rakovnická pahorkatina (Rakovnik highland), Plzeňska pánev (literally, Plzen pan), Podhorie Slovenských Beskyd (Foothills of the Slovene Beskydes), Prešovské hory (Presov mountains), Podtatranská brázdá (Sub-Tatra fold), Falknovský přikop (Falknov trench). A few names are rather more imaginative, *e.g.* Děčinske stěny (the Dečin "walls"), and the Sachsische Schweiz, north of the boundary has its counterpart in the České Svycársko to the south. In many cases the approved Czech names are already familiar to geographers in other forms: Malé Karpaty

(Little Carpathians); Bilé Karpaty (White Carpathians); Česky les (north-west portion of the Böhmer Wald; the south-east portion is the Šumava); Krušné hory (Erz Gebirge); Lužické hory (Lausitzer Gebirge).

A large proportion of the names, especially of the mountainous regions, has already been in use on the ordinary edition of the 1 : 200,000. It would require much study to determine what are the new proposals of the Committee, but these appear to be in the main for the lowland areas. The chief purpose of the maps is to give official status to regional names, already in use or proposed by the Committee, to show the limits within which they are properly to be applied, and to encourage the use of these names in geographical literature. A set of the maps has been placed in the Map Room for reference.

HYDROLOGY OF LAKE NAIVASHA, KENYA

Much detail is supplied by Mr. H. L. Sikes in "Notes on the hydrology of Lake Naivasha" which appears in the *Journal* of the East African and Uganda Natural History Society (vol. XIII, Nos. 1 and 2, 1936). Lake Naivasha, in lat. 0° 45′ S., long. 36° 20′ E., occupies a shallow pan in the Rift Valley, the drainage area rising above it to some 6000 feet eastward and 4000 feet westward. The volcanic rocks in the vicinity exhibit sharply defined craters, tuff cones, fresh lavas, and numerous steam vents. The drainage area is partly in the sub-arid and partly in the sub-humid zone, the average rainfall being assessed at over 40 inches a year on the east side and under 30 inches on the west. The annual evaporation is estimated at about three times the rainfall.

A record of the fluctuations of lake-level has been maintained with four short breaks since the end of 1908, readings being taken weekly; a bathymetrical survey was carried out in 1927 with sufficient precision to enable the volume of the water and area of the lake to be calculated approximately as the level varies; and between 1935 and 1936 a continuous record of the flow to the lake of the Melawa, Gilgil, and Karati rivers, draining most of the catchment area, was maintained. Since records were commenced the surface of the lake has varied from 6218 feet above sea-level on 17 November 1917 to 6195 feet on 21 February 1936, a range of 23 feet. The greatest depth of the lake is found on the floor of an extinct crater, about half a square mile in area, of which Crescent Island and the adjacent island form part of the wall. The depth of the water within the crater has varied from about 80 feet in 1915 to 57 feet in 1936. Latterly the level of the lake has been low, and it is thought that the lake may be reverting to the low-level stage which native reports and the evidence of tree stumps indicate to have prevailed between 1860 and 1880. Correspondence between lake levels and sunspots does not appear to be as strong in the case of Lake Naivasha as it has been shown by Dr. Brooks to be in the case of the larger lakes of the Rift Valley. It should be noted however that since 1923 this sunspot relationship appears to have broken down.

The author strongly supports the conclusions of Dr. Erik Nilsson that during the second Pluvial period the level of Lake Naivasha was about 400 feet higher than it is to-day, and that the lake dried up completely during two subsequent arid periods.

NORTHERN TURKANA

In Mr. A. M. Champion's paper on the "Physiography of the region to the west and south-west of Lake Rudolf" (*Geogr. J.*, February 1937) it is stated (p. 116): "In 1931, after unusually heavy rains, the R.A.F. officers who flew from Kapoeta in the Southern Sudan to Lokitaung reported a sheet of water at the northern extremity of the Lotogipi. Its existence has however never been

reported since." On the folding-map accompanying this paper a lake is shown approximately in this area with the inscription "Recently discovered lake."

We have received from Col. R. S. Cholmley an account of a visit he paid to this lake in 1927 in company with Captain F. P. A. Woods. The lake lies to the east of the hill Morunyang, about 12 miles south-east of Sevatt Ambo in Mongalla province. The Lomayen has cut its way through a low ridge which runs in a semi-circle from the south-west spur of Morunyang towards the northern point of Amora Gadel. This ridge banks up the flood waters of the Lomayen and Lotogipi, which inundate the area to the west. On the fall of the flood water, the inundated area recedes to the permanent bed of the lake east and south-east of Morunyang. In February 1927 flood water was still standing on the south. From Morunyang the lake appeared to extend towards Kaiserin. Natives stated that the lake was permanent, though it sometimes became very small and remained thus for a period of years. Two Abyssinian traders were encountered who were returning to Maji *via* Ambo; they described this route as being very important to the traders of Maji, and also spoke of the routes running north of Moru Akippi through Topotha to the Nile, thus providing the only practicable route south of the Sobat Pibor to the navigable Nile. Col. Cholmley suggests that this route could with very little labour be linked up to the Uganda road system. The position of this lake is shown on the "Map of the Uganda–Kenya, Sudan Corner" compiled by the 4th Battalion, King's African Rifles, and printed at the War Office in 1928.

THE CORDILLERAN SECTION OF THE CANADA–UNITED STATES BORDERLAND

We have been informed by Professor Jones that the correct values for the shadings on the map showing the "Percentage of British-born in total population" illustrating his paper in the *Journal* for May 1937 (p. 443) should be as follows:

0–1·75 1·75–3·5 3·5–7 7–28 28 and over